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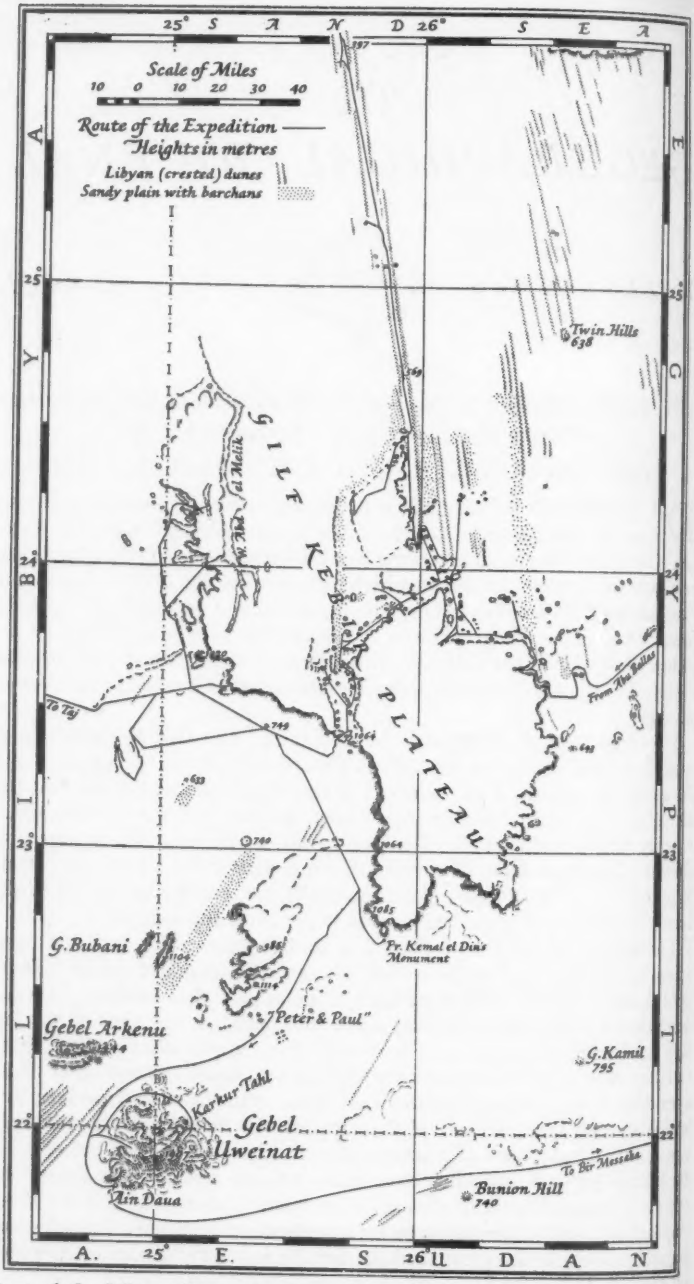
THE GILF KEBIR: *A paper read with the following at the Evening Meeting of the Society on 8 January 1934, by*

WING-COMMANDER H. W. G. J. PENDEREL, M.C., A.F.C.

DR. RICHARD BERMANN is to speak this evening on historical problems of the Libyan Desert, dealing particularly with the Gilf Kebir and 'Uweinat. My task in preceding him is to describe briefly the objects and results of the several expeditions which have attacked the Gilf, to give a more detailed description of our last expedition, and while I am doing so, to put the position before you geographically. We shall then have in our mind's eye a picture of 'Uweinat, the Gilf Kebir, and the surrounding desert, as they exist to-day. Dr. Bermann will take us back to the desert as it existed thousands of years ago.

We might start, I think, with the Gilf itself. The Gilf Kebir is a huge plateau or shelf resting on the Libyan Desert, in the form of a triangle with the apex to the south. The centre of it is about 450 miles west of the Nile and 600 miles south of the Mediterranean Coast. Its area, so far as we can guess, is roughly that of Switzerland. The escarpments on the west and east are precipitous. Our expedition discovered that it is divided by a large gap cutting right across it. The plateau slopes gradually towards the north and finally becomes submerged in the Sea of Sand to the north and north-east.

The Great Libyan Sea of Sand is a configuration which I do not think exists in any other part of the world. There are thousands of square miles of sand, more sand, and still more sand. A great part of it consists of parallel dune-lines running approximately north and south between 100 and 300 feet high, and anything, so far as I have seen, from a quarter of a kilometre to 12 kilometres apart. A line occasionally dies out, usually as two other dune-lines close on it; or it may connect itself to one of the flanking dune-lines by a bridge of soft sand. Except at these points the dune-lines are absolutely impassable by any form of motor transport. I have myself run between the dune-lines for over 150 kilometres without being able to make more than 15 to 20 kilometres to either the east or the west. It seems established without reasonable doubt—I trespass here for a moment on Bermann's domain—that somewhere within the great sand sea lies the lost army of Cambyses which left the Nile Valley for Siwa and was never heard of more.



Part of the Libyan Desert in the neighbourhood of the Gilf Kebir Plateau and Gebel 'Uweinat

Early last year the Sand Sea was crossed in cars from east to west for the first time by Mr. P. A. Clayton, of the Egyptian Desert Surveys, a very noteworthy feat indeed.

Some 70 kilometres to the south-west of the Gilf lie the three isolated granite massifs which rise sharply out of the plain—Gebel Arkenu, Gebel 'Uweinat, and Gebel Kissu. These three mountains are more or less in a line and about 15 miles apart. 'Uweinat is the central mountain and is appreciably the largest and highest, being about 18 miles long by 15 miles broad. The triple peak which crowns it is over 6000 feet above sea-level. Wells of very good water are found in several of its ravines. The water found at Gebel Arkenu is bitter and not drinkable except in an emergency. So far as is known there is no water at Gebel Kissu. The oasis of Kufara, until 1931 the stronghold of the Senussi, lies a little under 200 miles to the north-west of 'Uweinat.

The first explorer to sight the Gilf was Dr. John Ball, while on an advanced patrol during the War in 1917. Its true nature was however not realized until H.S.H. Prince Kemal el Din, on an expedition in 1926, ran parallel to and at no great distance from the south-eastern scarp of the plateau. It was the Prince, I think, who first gave the name of the Gilf Kebir to the plateau. Dr. Ball was one of the members of his expedition. Then came Bagnold, who from 'Ain Dalla forced his way south into the sand sea against great difficulties, and finally broke through on to the eastern boundaries of the Gilf. P. A. Clayton was next on the scene, and explored and surveyed up the west side of the Gilf approximately as far as latitude 23° 30′ N. It was he who discovered the first rock drawings in the Gilf. Clayton also discovered and surveyed the opening of the gap on the western side. It was thought then to be merely a big entrant.

We come now to the expedition of the spring of 1932, organized by the late Sir Robert Clayton-East-Clayton and Count Ladislaus de Almásy. They were fortunate enough to be able to co-opt P. A. Clayton as a member. I also had the privilege of taking part in the expedition. Three cars and a Moth aeroplane were taken to reconnoitre over ground which was impassable to the cars. The Gilf itself on the west side was the objective. Towards the very end of the expedition, and on one of the last flights over the Gilf it was possible to make, our petrol supply being nearly exhausted, the wadi with trees now known as Wadi Abd el Melik was discovered. Sir Robert Clayton and myself were the lucky occupants of the aeroplane. Every endeavour was made to reach the wadi by car with the remaining petrol, but in spite of a second short air reconnaissance by Almásy and P. A. Clayton, we failed.

In the latter part of 1932 and the early part of 1933 during the desert reconnaissance work of the R.A.F. squadron to which I belonged I was able to make two flights over the Gilf. The first was over the southern part, which I found was not an unbroken plateau, as it appeared when viewed from the ground, but was cut up into huge outliers. On the second flight I determined to follow the gap in the western side of the Gilf to see how far it penetrated. It ran first of all practically due north, in fact, a little west of north. I was on the point of turning back, my petrol reserve being the deciding factor, when through the haze ahead I saw that the gap had made an abrupt turn to the north-east. I cut the corner over the Gilf and now saw that it was swinging in

E G Y P T
L I B Y A
24°
23°30'
25°30'
25°0'
26°30'
Part of the Gilf Kebir Plateau showing the work of the Almásy-Penderel Exped. 1933.
Scale 1:1,000,000
Miles 0 5 10 15 20
Route
Heights in metres
Libyan (created) dunes
Sandy plain with barchans
Scarp
Supposed scarp
W. Hamra
Wadi Abd el Melik
W. Talh
Rock drawings
Stone circle

a wide semicircle towards the east. I was finally led out to the east side of the Gilf at the point where Dr. Ball had first seen it, and I recognized where I was.

Was this gap possible for cars? That was the question that I determined our next expedition—which was already at that time almost completely organized—must answer.

I will not weary you with our initial work of preparation. It is sufficient to start from the point where our organization was complete. I do wish however to acknowledge with very grateful thanks the valuable help and assistance given us by Abousbah Bey, His Excellency Abrashi Pasha, Dr. John Ball, Messrs. Murray Clayton and Walpole of the Egyptian Desert Surveys, Air-Vice-Marshal Newall, and His Excellency Wasfi Bey.

The members of the expedition were Count Ladislaus de Almásy, Dr. Kádár, a geographer and geologist of the University of Budapest, Herr Casparius, photographer and cine-photographer, Dr. Bermann, whom you will hear to-night, and myself. The native personnel consisted of two Sudanese drivers and one cook. For our transport we had selected four A-type Ford cars with box bodies. Our equipment was with two exceptions typical desert equipment. For the first time on any desert expedition the new enormous balloon tyres known as air wheels were tried. The tyres are 9 inches wide and are intended to be run at 12 lb. pressure. We were however forced to run them in the neighbourhood of 20 lb. owing to our very heavy loads. We knew, having tested them, that they were excellent in soft going. The gamble was whether they would stand up to the work over stone fields and rocky ground. There were two schools of thought, one that the tyres would get cut badly owing to their low pressure; the other that the low pressure was advantageous, as there being less resistance, stones would be merely pressed into the tyre without damaging it. The latter school fortunately was correct, and although of course we had badly cut tyres and internal fractures of the fabric, they were certainly not more than one gets with the ordinary size tyre. Over the real liquid sand however they were as useless as ordinary tyres. They even had a disadvantage, as owing to their bigger surface a car once stuck was considerably more difficult to get out. I doubt whether a car on any tyres can be driven through liquid sand.

The second new item of equipment was an aeroplane compass with a rotating grid ring, which I tried as an experiment. Almásy was using a different type fitted with a card. I found the compass very excellent indeed, easy and not fatiguing to read.

Before we left Cairo on the start of the expedition we had already heard the exciting news sent back by Clayton, who was then surveying in the northern part of the Gilf, that he had succeeded in getting into Wadi Abd el Melik from the north. Our initial plans were to explore the east side of the Gilf and to try to make a passage through the gap in the Gilf from east to west. Further plans we left to circumstances.

Our jumping-off point was Kharga. We left on March 22, our first objective being Abu Ballas, known also as Pottery Hill, and from there we made an excursion to Rohlfs' Regenfeld. Our next move was to make a base in the eastern entrance to the gap. From here we sent two cars to Bir Messaha,

about 150 miles to the south-east, to replenish our water supply. During our exploring to the north we suddenly came upon two recent car tracks leading from the west and coming out of the gap. We realized of course they were Clayton's, and after a kilometre or two "read" them as one car on its outward and return journey.

We continued our exploration northward across the mouth of the gap, which at this point was very wide, over good sand going, through fairly widely separated outliers and small hills. We were in search of the scarp of the northern part of the Gilf, and we found it after going north about 35 miles. It was running practically due east and west and was guarded by what appeared to be an impregnable wide line of complex dunes. A point where this line piled up in huge breakers against a small promontory of the Gilf offered the only chance of crossing.

After about three hours' reconnoitring on foot a "perhaps possible" way was "stamped out" to avoid the invisible pools of liquid sand lying hidden in the dune-line like so many big traps. The way led over the tops of the rounded dunes and along the crest itself of the crested ones. It is here that the hard sand is found. To an onlooker the passage of the cars across the dune-line must have looked, as the cars appeared and disappeared among the dunes, more like a White City scenic railway than anything else. A trial run was made with a lightly loaded car, and then all cars were got safely across and the edge of the Gilf followed to the east.

After some 30 miles this scarp of the Gilf ended in a very high hill, and on climbing it we found that we had been running along the southern side of what I can best describe as a long cape jutting out of the main body of the Gilf, which we could now see away to the west at a distance of about 25 miles. The scarp of the main body was, we estimated, running more or less north and south, and continued as far as we could see. To the direct north was a most wonderful sight: the sand sea with all its ordered lines of dunes marching northward as far as the eye could reach.

We were now within a week of the time when we had arranged to try if possible to meet P. A. Clayton at Kufara. Leaving one car at this, the farthest point we had reached, we went back with the remaining three to the entrance to the gap and started westward along it with hope in our hearts but much doubt in our minds. On we went over good going, the outliers and walls of the Gilf closing in on us on each side. We pressed on farther, meeting no obstacles, now in a south-westerly direction. Then we swung round and ran due south on the last lap, to arrive finally on the edge of the shelf of the gap overlooking the open route to Kufara. An easy descent down a large wadi brought us on to the plain, where we camped that night, well satisfied.

On our arrival at Kufara we were received by the Military Governor and the officers of the garrison. Their hospitality and the help they gave us were unlimited and left us greatly in their debt. It was here that we became aware that Clayton had received most able reinforcements in the shape of Lady Clayton-East-Clayton and Commander Roundell's expedition, and that they had left Kufara on their return to the north part of the Gilf only that morning. They left word for us that their expedition had discovered a second wadi to the east of Wadi Abd el Melik. Certain information we

One of the planted "'alamat"

Loaded cars en route

Phots. H. W. G. J. P.

Extricating a stuck car by means of jacking up and laying a track of stones

Aerial photograph taken while flying over the Gilf, showing outliers

A wadi in the Gilf

The head of a wadi

Phots. H. W. G. J. P.

received from a Tebu guide in Kufara convinced us that there was still a third undiscovered wadi in the Gilf and that these three wadis must be the three wadis written of by Wilkinson in 1838; so after overhauling the cars we left for the west side of the Gilf to try and locate the third wadi.

We made our starting-point for the search the old camel track on the top of the Gilf we had found the previous year. We discovered the actual descent of the camel route from the top of the Gilf to the plain, and by the track on the plain we found the skeleton of a cow, and felt we were hot on the trail. But further than this we had no success, in spite of a 20-mile search on foot on the top of the Gilf.

It was then agreed that Almásy should continue to pursue the search for the third wadi while I was to return through the gap with Kádár, one driver, and one car, to the point where we had left the fourth car, and from there attempt to get completely round the Gilf and rejoin the rest of the expedition—in effect a circumnavigation of the Gilf. We got back to the guardian dune-lines I spoke of previously. I went forward again as a matter of precaution to reconnoitre the passage, and found to my astonishment that the whole dune-line here had completely changed. Our tracks had been completely obliterated. Crested dunes had changed to "mound" dunes and *vice versa*. New dunes were forming, many of the smaller dunes had vanished. We again got through safely, but over a new route and with more difficulty. On arriving at the car another surprise awaited us—fresh car-tracks and a message from the Clayton and Roundell party tied to our car, wishing us luck and telling us how they had got there. I knew Clayton's route to Kufara was round the north of the Gilf, and realized that a circumnavigation of the Gilf had been already accomplished, although in two parts, the northern by the Clayton party, the southern by us.

I then of course abandoned the idea of going round to the north, and explored the top of the Gilf itself. Luckily I found a route by which we could get a car on top. I made one most interesting discovery, that of a curved line of '*alamat* of a type so far as I am aware previously unknown. Each '*alem* was in the form of a stone pillar about $3\frac{1}{2}$ to $4\frac{1}{2}$ feet in length. Each had been planted firmly in the ground to a depth of about $1\frac{1}{2}$ feet in an upright position. No trace whatever of any track remained. As we had a little time left before the appointed day of rejoining the others, we made a run northward into the sand sea for about 150 kilometres between the impassable parallel lines of dunes I have spoken of. Progress to the east or west, except a kilometre or two occasionally, was impossible.

Our return was made through the gap to a prearranged meeting-place on the western side of the Gilf where we found the rest of the expedition waiting for us, with the news that Almásy with one of the natives had, after driving some 20 kilometres farther north, made a reconnaissance on foot into the Gilf and had found the third wadi. The credit of this discovery must rest wholly with Almásy.

Our next move was to 'Uweinat, where we knew from the Governor at Kufara an Italian survey party was camped. It was at 'Uweinat in the boulder caves above the well called 'Ain Daua that the discovery of the extraordinary rock paintings was made.

Almásy's arrangements made it necessary for him now to return to Cairo. I was in no hurry to return, having still some of my leave left, and so we decided to divide the expedition. I, with two cars and three natives, went on to try and get to Merga by a new and more direct route than that previously traversed by Prince Kemal el Din. Almásy, with the rest of the expedition and the remaining two cars returned to Cairo *via* Terfawi and Kharga.

I found a new route to Merga, but not without many difficulties, including a broken car, which we had to repair. We were five days on the road. The hard work we had to do during the day in the heat of the Sudan sun (it was then May) led to a very heavy over-consumption of water, the daily ration imperative being three to four times the normal. Before I left 'Uweinat the Italian party told me they had information that the Guran robber named Gongoi was at Merga with his band. This was the same band that had attacked a Dongalese caravan some time previously and murdered its members. On reaching Merga and dropping down into the depression I went forward on foot to reconnoitre, and to find out if the robbers were in residence. I discovered a camp and found that I also was being reconnoitred by two scouts. It was then approaching dusk and was too late to try to establish contact with any safety. It was impossible to remain there open to attack during the night, so, making a detour to avoid any possible ambush, I picked up my outward tracks and went back along them out of camel range.

My water supply was now dangerously low, and a review of the position and a check of the petrol remaining that night made it obvious that there was no alternative to a return to 'Uweinat. The return journey was made without incident. From 'Uweinat I returned to Cairo *via* Kharga.

HISTORIC PROBLEMS OF THE LIBYAN DESERT: *A paper read with the preceding at the Evening Meeting of the Society on 8 January 1934, by*

DR. RICHARD A. BERMANN

MY interest in the Libyan Desert was first excited by my Hungarian friend Ladislaus Edward de Almásy. For a number of years he used to spend his winters in Egypt and the Sudan; he had become one of the pioneers of motoring in the desert. When he came back he used to tell me about his latest exploits and his further plans. Soon he had become fascinated by the old Zerzura problem, and he would discuss it with me. Since the times of the ancient Egyptians, he explained, there had been a vague but persistent rumour about fertile lands lying in the desert west of the Nile. The famous expedition of King Cambyses's army against the oasis of Jupiter Ammon could hardly have been planned if the existence of water somewhere in the middle of the desert had not been known. All through the Middle Ages Arab writers had told about a hidden oasis; the name of *Zerzura*—meaning probably "Oasis of Little Birds"—had been mentioned for the first time in the thirteenth century.

Almásy would quote to me the Arab legends of the "Book of Hidden

Treasures" (Kitab el Kanuz), where the fabled Zerzura is described as "a white city, white as a dove. Above the closed door you will see a bird, carved in stone. Open the door and enter. You will find much riches. In the palace the King is sleeping with his Queen; they sleep the sleep of the enchanted. Don't go near them, only take the treasure." But Zerzura, I understood, was not only supposed to be a place of hidden treasures, but also a danger spot of the desert, wherefrom black giants would emerge to attack the Egyptian oases. The anonymous 'History of Siwa Oasis' mentioned a southern "land of unbelievers."

After having alluded to those tales Almásy would explain to me that his own belief in the existence of some unknown oasis was largely based upon the relation of I. G. Wilkinson, the first European who ever heard the name of Zerzura. He mentions in his book published in the year 1838 that natives of Dakhla had told him about an oasis lying west of the caravan route Farafra–Bahariya and called Wadi Zerzura. This oasis was said to contain many palm trees, springs, and ruins of an uncertain age. According to another story, Wilkinson said there are three wadis forming Zerzura. They were used for grazing. Beyond them followed the oases of Kebabo, Taizerbo, and finally Wadi Ribiana. These oases, part of the Kufara Group and entirely unknown in Wilkinson's times, had been duly discovered later on, but the three wadis of Zerzura were, Almásy pointed out, still believed to be a mere fable. But why should the Dakhla people, who informed Wilkinson, have known and told the truth about the oases lying farther west and have lied about a place supposed to be so much nearer to their home?

Almásy had come to the conclusion that Wilkinson's three mysterious wadis —wadis containing water and vegetation—must lie somewhere in the interior of the Gilf Kebir, whose heights were likely to attract the tropical rain clouds. If one or several rain oases with at least intermittent springs existed in the Gilf Kebir many dark problems of African history could easily be explained, from the campaign of King Cambyses down to the Senussi raids during the world war. Black raiders coming from the West had attacked the civilized oases of Egypt many times during the centuries; if they came from Kufara or from Tibesti how could they have crossed the desert if there was no water nor pasture in the middle of this enormous distance?

Believing that the solution of the riddle lay in the Gilf Kebir, L. E. de Almásy organized, together with the late Sir Robert Clayton-East-Clayton, Mr. Patrick A. Clayton, and Wing-Commander (then Squadron-Leader) H. Penderel, their memorable expedition of 1932, in the course of which they explored great parts of the Gilf Plateau, and finally saw and photographed, flying over the northern Gilf, a long wadi with many trees in it. Unfortunately they were not able to land there or to find the entrance from the desert plains; but Almásy felt sure they had found one of Wilkinson's three wadis, and that the other ones existed nearby. Therefore a new expedition had become necessary. The late Prince Kemal el Din had generously offered to outfit this expedition. After this great explorer's premature death our plans were disarranged; finally we somehow contrived to make possible our expedition, which started on 14 March 1933 from Cairo. Contemporaneously, Mr. Patrick Clayton, Almásy's late companion, led another expedition into the

Gilf region; he was joined by Lady Clayton, Sir Robert's widow, and by Lieut.-Commander Roundell.

Wing-Commander Penderel, who was with Almásy the joint leader of our expedition, has outlined in his paper the main geographical features of our expedition; I am now only concerned with the historic and archaeological problems we tried to elucidate. Starting from Kharga with four Ford motor cars our expedition, composed of five Europeans and three natives, first visited the curious Pottery Hill, situated about 300 miles west of Kharga. The site had been discovered by Dr. John Ball on his motor patrol during the War in the year 1917 and explored later on by Prince Kemal el Din, who gave it its Arab name, Abu Ballas—"Father of Jars." Both names of the place are explained by the fact that at the foot of this desert hill there lies a deposit of large earthen jars. Kemal el Din (who wrote a learned paper about the place) counted about three hundred such jars; he took some of them with him to Cairo. We still found and took with us some relatively intact ones; all of them are broken and many entirely destroyed. Some of these jars have a shape still used by the desert people, but many show the unmistakable shape of the classic Greek amphora.

Prince Kemal el Din had heard in Dakhla old natives say that this deposit of water-pots in the desert had first been found in the middle of the nineteenth century by a party of Dakhla people who had repelled an attack of desert raiders on their oasis and then followed the flying *razzou* into the desert. When they found the deposit of the robbers the Dakhla warriors carefully broke all the jars—a thing to be deplored from the archaeological standpoint but otherwise easy to be understood; undoubtedly this hidden place in the desert had been a point of support to the robber caravans who had used to raid the Egyptian oases through so many centuries.

When we rested in Abu Ballas, Almásy showed me the map. Tracing a rough line from Dakhla to Kufara he explained that Abu Ballas was situated at the end of the first third of the distance. Was it not likely that at the end of the second third the raiding caravans must have had another point of support containing water and food for their camels? Was this second point another deposit of jars, or was it the wadi of Zerzura in the Gilf Kebir?

Prince Kemal el Din had discovered on the rocks of Abu Ballas some prehistoric rock engravings showing figures of men and animals. So this place had been known to mankind long before the time when Greek amphorae were in use. But how could these amphorae have come into the desert?

As the expedition's official chronicler I was in charge of our travelling library, which, I am sorry to state, mainly consisted of one book: of the 'Histories' of old Herodotus, the best Baedeker of the Libyan Desert still existing. Having this book only I had come to know it rather well, and so, in the sight of the jars of Abu Ballas, I read to my companions the following passage from the sixth and seventh chapters of the Third Book of Herodotus:

> I shall now mention a thing of which few of those who sail to Egypt are aware. Twice a year wine is brought into Egypt from every part of Greece as well from Phoenicia in earthen jars; and yet in the whole country you will nowhere see, as I may say, a single jar. What then, every one will ask, becomes of the jars? This, too, I will clear up. The burgomaster of each town has to

Aerial photograph of the southern cliffs of 'Uweinat: the well 'Ain Daua at the foot of the cliffs

Phots. H. W. G. J. P.

Aerial photograph of the above from lesser distance, showing site of 'Ain Daua and the rock paintings

The rock paintings: warrior with bow and decorative anklet (top left) and man and woman in supposed cave opening (bottom right)

Phots. H. W. G. J. P.

The rock paintings: typical examples from one of the other caves

collect the wine jars within his district, and to carry them to Memphis, where they are filled with water by the Memphians, who then convey them to this desert tract of Syria. And so it comes to pass that all the jars which enter Egypt year by year, and are there put up to sale find their way into Syria, whither all the old jars have gone before them. This way of keeping the passage into Egypt fit for use by storing water there was begun by the Persians so soon as they became masters of that country. . . .

Looking at the amphora-shaped vessels of Abu Ballas we remembered that army of the Persian king which had perished in the desert on its march to Siwa. Even a crazy oriental despot could not have sent an army into the desert if he had not known of some deposits of water there. Could not Abu Ballas, we dreamed, have been one of the water deposits of the Persian army on its way to Siwa—if this way had led, somewhat circuitously, but avoiding most of the Sand Sea, to the wadis of Gilf Kebir and from there to the oasis of Jupiter Ammon?

After leaving Abu Ballas our expedition travelled to the east side of the Gilf Kebir and started exploring and mapping the outline of this little known mountain region. We had hoped to discover the entrance to one of the three wadis there, but did not find any traces of vegetation. Finally, having discovered a broad gap dividing the Gilf into two distinct parts and found that it could be negotiated by motor cars, we crossed the Gilf, arrived at its west side, and finally went to Kufara for water, petrol, and victuals.

We were most hospitably received by the Italian garrison of Kufara, and spent a week there. A few hours before we arrived in Kufara, Lady Clayton and Lieut.-Commander Roundell had left the oasis, and we learned that the Clayton expedition had successfully entered the wadi which had been sighted from the air a year ago. Almásy at once decided to visit this wadi too, in order to get better bearings for the discovery of the two other fertile wadis he was sure he would find—Wilkinson's wadis. We had reasons to expect that the natives of Kufara, especially the Tebus, had always known of the existence of these wadis, and so we tried to make them speak.

I shall always remember a conference we had in the old Senussi fortress of Djof, in the hall which once had been the library of the Great Senussi Sheikh. Almásy was asking questions of Ibrahim, an old Tebu who was by profession a caravan guide: a snake-like, mysterious old man, quite black. He spoke Arabic with a strong accent, which made us nickname him Nyiki-Nyiki. For the first time I heard that language "like the screeching of bats" which Herodotus mentions.

The influence of the Senussi creed is still strong in Kufara, and not to reveal the secrets of the desert to the stranger had been one of the foremost doctrines of the Senussiya. But knowing of the existence of at least one of the wadis, Almásy could persuade old Ibrahim to tell us a little more. He called the wadi entered by Mr. Clayton Wadi Abd el Melik, and said that another valley with trees, Wadi Talh, was situated near it, describing its whereabouts so that we could hope to locate it. He would not confess then the existence of a third wadi.

Wadi Talh means the Wadi of Acacias. Abd el Melik (Servant of the King) is, of course, a common Arab name, meaning a servant of Allah, but I could not help being thrilled by it, thinking of King Cambyses.

We left Kufara on April 26 and proceeded to a place near the west side of the Gilf, called Chianti Camp by the Almásy-Clayton Expedition of 1932. From there my companions—I being sick in camp—tried to discover Ibrahim's Wadi Talh by climbing the stone wall of the Gilf Plateau. They found old camel tracks leading to the Gilf; then a distinct path, evidently man-made, and near it not only camel bones but also the skeleton of a cow; also the sleeping places of the Tebu herdsmen. It became quite evident that this path had been used only a few years ago to drive camels and even cattle up to the mountain pastures. But when my friends had climbed the plateau they were not able to reach the supposed Wadi of the Acacias. They returned to Chianti Camp and we decided to divide the expedition: Wing-Commander Penderel and our geographer, Dr. Ladislas Kádár (of the Budapest University), motoring through the Gap to the north-eastern Gilf, in order to continue the map-making there, while the rest of the expedition was to try again to find that elusive wadi.

From Chianti Camp we visited a place in the outliers of Gilf Kebir where Mr. Clayton in 1931 had discovered a cave with many Stone Age engravings, showing cattle and wild animals, mostly giraffe. We were fortunate enough to find a second cave with many giraffe and lion pictures engraved in the rock, and near it many Stone Age implements, especially grinding stones. Looking at the landscape I imagined that this settlement must once have been situated on the shores of a prehistoric lake, possibly amongst tropical vegetation. This guess, rather hazardous at the time, seems to have been confirmed by later discoveries.

Proceeding from Chianti Camp farther north we penetrated on May 3, following the car tracks of the Clayton Expedition, into Wadi Abd el Melik, which we found a rather dreary, long valley, where hundreds of acacia trees of different species were growing. We found the trees still green, but the rest of the vegetation withered; in the two rock springs we found only a few drops of moisture. The sites of several Tebu camps could easily be recognized; we found remains of their grass huts, baskets, etc., and much camel dung. There were many fresh tracks of Barbary sheep (*waddan*) to be seen; birds of a species unknown to us were very conspicuous, justifying the name of the Oasis of Little Birds; otherwise the valley seemed empty. It was evident that in these rain oases of the Gilf life can only persist a few years after a big rain period, and that sometimes the wadis will die out—which perhaps explains the sporadic disappearance and reappearance of the Zerzura legend through the centuries.

After visiting Wadi Abd el Melik we tried once more to find Wadi Talh. Following some old camel tracks we drove into the bed of a dry mountain torrent and camped there. On May 5 Almásy, accompanied only by one of our native drivers, climbed the almost insurmountable stone wall of the Gilf, found on the plateau the marked path again, and finally saw a broad wadi filled with green acacia trees. He had found Wadi Talh, the second of the three Wilkinson wadis. Our expedition did not find the third of Wilkinson's three wadis. But when a few days after having discovered Wadi Talh we visited the spring of 'Ain Daua in the 'Uweinat Mountains, we found there an Italian military mission, occupied with map-making, and as their guide our old friend Ibrahim.

This time again he showed great reserve, but he unbent when we told him about the dead cow we had found on the path leading to the wadis. Grinning, he confessed that he had himself lost this cow only a few years ago, when driving the herds of a certain Abdallah into the wadis. It came out that in the years after a rain the people of Kufara (where grazing lands do not abound) used to send their camels and cattle into the Gilf Kebir, where the three wadis provide pasture and water for a long time. Yes, there are three of them. Ibrahim named and described the third and smallest of them, Wadi Hamra—the Red Wadi. (This wadi has actually been found and entered by Mr. Patrick Clayton during his expedition. He was gratified in learning from us its native name.)

So Wilkinson's old tale was true. There are three verdant wadis in the Gilf Kebir—verdant after a big rain and sometimes quite desiccated, it seems. Are they Zerzura? Old Wilkinson said so!

In 'Uweinat we had to wait for Wing-Commander Penderel, who had gone to Kharga with two of our cars. We lived with the members of the Italian mission in the narrow circle of granite boulders that surround the spring of 'Ain Daua. It was May, and the heat was terrific amongst the stones. The only refuge we found was in certain caves, or rather holes, with which the granite walls of 'Uweinat are honeycombed. These grottoes, which offered some protection against the heat, had been used during this winter by Major Bagnold's expedition, by the Italians, and by a party of British airmen—yet nobody had discovered that a little higher up similar little caves contained the most wonderful documents of an old civilization.

It was Almásy who found the first of these caves and showed it to Professor Ludovico di Caporiacco, of the Italian mission, and to me. Two hours later about a dozen more of these caves were located, all covered with beautiful rock paintings in four colours, showing cattle and other animals, mostly tame ones, and human beings: dark-skinned warriors with bows in their hands, with many ornaments and with plumes in their hair. The most interesting picture represented the cave itself, surrounded by a circle of granite boulders, and in it an interesting pair: a slender man and an enormous lady—evidently Monsieur and Madame, the owners of this cave, who had decorated their home with their portraits. Near the caves Dr. Kádár collected many Stone Age implements. Our photographer, Mr. Hans Casparius, photographed the cave paintings and Almásy made some colour sketches.

When, ten years ago, A. M. Hassanein Bey had discovered 'Uweinat, the natives had told him that the *djinn* had lived around these wells in the olden times, and that they had left upon the rocks "writings and drawings of all the animals living." When Hassanein explored the *karkurs* (valleys) of 'Uweinat he indeed discovered drawings of animals deeply engraved in the rocks; and Prince Kemal el Din even found in Karkur Talh a very few *painted* pictures; but nobody had known of the enormous masses of rock-paintings hidden in the caves—the first elaborate coloured paintings ever discovered in this part of Africa. The Tebu and Goran guides of Hassanein must have thought of these caves when they told Hassanein about the pictures made by the *djinn*. For we found evidence that modern Tebu or Goran had inhabited the very caves only a few years ago.

Again a passage in Herodotus seemed to me to explain the history of these painted caves. In his fourth book (Chapter 183) the Father of History speaks of a nation of Libyan cave dwellers:

> Ten days' journey from Augila there is again a salt hill and a spring; palms of the fruitful kind grow here abundantly. . . . This region is inhabited by a nation called the Garamantians, a very powerful people. . . . In the Garamantian country are found the oxen which, as they graze, walk backwards. This they do because their horns curve outwards in front of their heads so that it is not possible for them when grazing to move forwards, since in that case their horns would become fixed in the ground. . . . The Garamantians have four-horse chariots, in which they chase the Troglodyte Ethiopians, who of all nations whereof any account has reached our ears are by far the swiftest of foot. The Troglodytes feed on serpents, lizards, and other similar reptiles. Their language is unlike that of any other people—it sounds like the screeching of bats.

More than one explorer has observed how much this description of the black cave dwellers of Herodotus fits the Tebus of to-day; their swiftness of foot is a well-known fact, and whoever heard a Tebu talk knows what old Herodotus means by the screeching of bats—our friend Ibrahim-Nyiki-Nyiki certainly sounded like that. But why should Tebus be called Troglodytes—cave dwellers? And now we had found south of Kufara (which might quite well have been a part of the Garamantian country) caves certainly inhabited in the olden times by black people whose portraits seem to me to show quite the very characteristic type of the Tebus of to-day; modern Tebus had lived in the caves only a very few years ago. The conclusion that they were the lineal descendants of Herodotus's black cave dwellers does not seem so fantastic to me. By the way, one of the pictures we copied shows an ox or cow with horns distinctly curved outward.

The discovery of the painted caves of 'Uweinat was the last our expedition made. We knew at once that we had only searched a small part of the caves, and felt that another expedition, led by archaeological experts, was desirable. We did not doubt that it would make many more important discoveries in the 'Uweinat area, and also near our Giraffe Caves.

While Wing-Commander Penderel undertook another interesting excursion to Merga, Almásy, Dr. Kádár, Casparius, and myself followed the Darb el Arba'in to Kharga and arrived safely in Cairo on May 24.

The new expedition to explore the caves of 'Uweinat was undertaken a few months later—in October—by Professor Leo Frobenius, of Frankfurt, who persuaded L. E. de Almásy to guide him to 'Uweinat, Kufara, and the "Giraffe Cave" we had found near the Gilf, and to point out to him the pictured caves. Following the tracks of our expedition and guided by Almásy, Professor Frobenius's expedition found a wealth of highly interesting rock paintings, especially in the *karkurs* of 'Uweinat, and many stone implements. It cannot be within the scope of this present paper to describe them. But it seems very important that not only 'Uweinat turned out to have been an important centre of Stone Age civilization, but also the western slopes of Gilf Kebir—near our three wadis. When the Frobenius expedition had arrived at the place where Clayton and ourselves had found the giraffe engravings, Almásy, exploring the rugged valley towards the Gilf, was fortunate enough to find many wonderful

coloured cave paintings showing amongst other things people in the unmistakable posture of swimmers—so there had been a lake after all! The three newly found wadis of the Gilf—Wilkinson's Zerzura—have not yet been searched for rock paintings; I think they must contain many of them. But already the discoveries near the Giraffe Caves (Almásy called the place Wadi Sura—Valley of Pictures) prove that the Gilf Kebir had been in the olden days a fertile region, inhabited by mankind; in consequence there is some foundation in the old legends, which always told of "cities" and verdant lands in the middle of the Libyan Desert.

But Zerzura? I dare not pretend that we really found the fabled "Oasis of Little Birds." Who knows what the Great Sand Sea still hides? Almost contemporaneously with our expedition Lieut. Orde Wingate, R.A., undertook his plucky march into the Sand Sea around 'Ain Dalla. He did not discover any oasis, but he found many interesting artefacts. It does not seem impossible that some unknown depression in the Sand Sea may still hide wells, palm trees, and, for all we know, the ruins of "the white city" of Zerzura. Personally I almost hope the beautiful old legend will never quite be cleared up by a mere discovery.

DISCUSSION

Before the papers the PRESIDENT (Major-General Sir PERCY COX) said: The title of the lecture advertised for this evening is "Historic Problems of the Libyan Desert," but as you see two lecturers on the platform I think perhaps I had better give the meeting a little explanation of the circumstances attending this lecture. We were going to hear a lecture on the expedition to the Cameroons by Mr. Ivan Sanderson, but, unfortunately, he fell ill, and the doctor would not allow him to give his lecture. But Wing-Commander Penderel and Dr. Bermann, whom we were asking to lecture a little later, very kindly agreed to put their date forward and give their papers this evening. Unfortunately Wing-Commander Penderel was abroad at the moment, and we could not be quite sure whether he would arrive in England in time to be with us, in which event Dr. Bermann very kindly undertook to take the whole duty upon himself, and we are grateful for his co-operation in the matter, for you will, I know, realize how difficult it is to fill a date at short notice. I am glad to say the Wing-Commander arrived in time to participate in the lecture to-night.

Dr. Bermann and Wing-Commander Penderel went on this expedition to the Libyan Desert together. Wing-Commander Penderel, as you may assume, is a squadron officer of our own Air Force who was stationed at Cairo and on two occasions was able to obtain leave from his duties to go on expeditions in the Libyan Desert.

Dr. Bermann is a man of letters and the author of several works; among them, his well-known book, 'The Mahdi of Allah,' which has been translated into English. In writing that book Dr. Bermann came into close touch with Slatin Pasha, whose death we so much regretted, and also with Sir Reginald Wingate, the then Governor-General of the Sudan, with whom he is on close terms of friendship.

The expedition from the start met with extraordinary ill-luck. Most of you, I am sure, remember the tragic circumstances of the death of Sir Robert Clayton-East-Clayton, followed later by the death of Lady Clayton-East-Clayton. Sir Robert Clayton was just about to join Wing-Commander Penderel, but, alas, he died in England of some strange malady, blood or ptomaine poisoning, a

fortnight before he would have joined Commander Penderel. Lady Clayton courageously took on his mantle and went out to the Libyan Desert to endeavour to carry out what her husband would have done. She was accompanied by Lieutenant-Commander Roundell, who is with us to-night. I cannot call upon the readers of the paper to begin their address without referring, very sympathetically, to those tragic occurrences.

The lecture, as I have said, is concerned with the Libyan Desert, a region to which in the last twenty years a great deal of attention has been paid by explorers. Undoubtedly the opening up of the Libyan Desert, like the exploration of the great Arabian desert, is filling what was a most humiliating blank on the map. I think that must be one of the reasons for the lively interest in that area. Another reason perhaps why attention has been paid to it is that it has an air of mystery about it. Both the great Arabian Desert and the Libyan Desert have that. As to the great Arabian Desert you will remember hearing a good deal last year of the legendary ruins of Wabar, and in the Libyan Desert we hear of a mysterious oasis of "Zerzura." Whether or not we are to hear to-night about Zerzura, it seems to me indiscreet to inquire, but I hope we may.

Now that Wing-Commander Penderel has been able to come and participate in this lecture he is going to speak first on the geographical aspects of the expedition. He will be followed by Dr. Bermann, whom we are glad to welcome to-night. We are also honoured by the presence of a distinguished diplomatist, the Austrian Minister, who represents the country from which Dr. Bermann hails. I will now ask Wing-Commander Penderel to address us on the geographical aspects of the expedition.

Wing-Commander Penderel and Dr. Bermann then read the papers printed above.

H.E. THE AUSTRIAN MINISTER: When we Austrian diplomats, who, like migratory birds, have our home in many lands, meet our compatriots abroad we tease them by asking them whether they are suffering from the "*Stephansturm-Krankheit*"—the home-sickness for St. Stephen's Cathedral in the centre of Vienna—because we all know how great the lure of Austria is and the desire of the Austrians to live at home.

But in many the interest in geography and science and the love of adventure and of living dangerously are irresistible. Thus Slatin Pasha, equally beloved in Austria and in Great Britain, whose friendship I had the privilege to enjoy, went to the Sudan as a young lieutenant, rose to high position there and rendered signal service to the British Empire. The explorer Payer, supported and accompanied by Count Wilczek, went on a quest for the North Pole and discovered an arctic region which he named Franz Josef Land, after the Austrian Emperor. Austrian scientists have for more than thirty years been engaged in clearing the site of ancient Ephesus and bringing to light the monuments of its great past.

One of the newest of Austrian explorers, Dr. Bermann, has told us a thrilling story of his expedition in the Libyan Desert. The President said in his introductory remarks that there was an air of mystery about it, and I can well understand that it attracts men of daring and imagination.

Before I speak further of Dr. Bermann I want to say that there is a curious connection between us two, because we were for a considerable time fellow-prisoners. We were not fellow-prisoners, as you may imagine, in the deserts in the heart of Africa; we were prisoners, as it were, in the heart of France during the peace negotiations. It is true that very comfortable quarters were placed at our disposal, but we were surrounded by French policemen and they gave us a small corner of the terrace at St. Germain to walk up and down. But those times are far away and will never return.

Dr. Bermann is a brilliant essayist and novel-writer, also a fine archaeologist with a gourmet's interest in cultures and civilizations off the beaten track. Travelling all over the world, he has cultivated in the last twelve years the field of the travel essay, combining geographical and literary aims, and has deservedly earned great recognition. It gives me much pleasure to congratulate him on his achievements and on the able way in which he has described them to us. I am very pleased to have been here to-night to listen to him, and proud that a compatriot of mine has rendered such distinguished service to science.

I will not detail you further because I am sure you all feel, like myself, a desire to return and to read that wonderful book of Herodotus, and then go to bed to dream about Ethiopian troglodytes.

In conclusion, may I express to you, sir, my warm thanks for having invited me to your dinner this evening and for having allowed me to be present at this most interesting lecture. And may I express the wish that your great Society may continue with ever-increasing success its great work for the benefit of science, the glory of Great Britain, and the enlightenment of humanity.

The PRESIDENT: I will now call upon Professor Myres, who, as you know, is Wykeham Professor of Ancient History in the University of Oxford.

Professor J. L. MYRES: It is with very great pleasure that I take this opportunity of congratulating Dr. Bermann on his extraordinarily interesting discoveries. I should like also to say how greatly I appreciated the opportunity of hearing what Wing-Commander Penderel told us about the geographical conditions under which those archaeological discoveries were made, and under which those ancient remains came to be where they were. I imagine what impressed us all was the surprising variety of scenery and land-forms in what we are all familiar with in modern times as a great desert area. We have had presented to us on previous occasions the geography and geographical problems of the great depression of the Kharga oasis. We have heard to-night of similar depressions farther west, and Wing-Commander Penderel has made vivid to us at all events the outlines of that great up-raised or prominent slab which has presented so many problems and brought together such a variety of ingenious theories by way of explanation. I think particularly of what we were told about its altitude. When you have a high plateau going up to some 6000 feet it puts into a new perspective the problem of differential desiccation in the long climatic process which has brought the Libyan Desert into its present condition, and makes more intelligible the discovery, even in this late date of that process, of a real oasis, in a sense that it is a remnant of a geographic régime which formerly had a much larger extension and to which its remains of dead trees, surviving trees, birds, and other small creatures, still give a coherent biological as well as climatic existence. That is a striking contribution to geographical knowledge, and heartiest congratulations are due to all those who in such various ways have contributed to drive home this geographical conclusion.

Nothing was more striking in the narrative put before us to-night than the way in which one clue after another, like a well-constructed detective story, gradually built up a scheme of knowledge, challenging at each stage further activity, further exploration, and raising, in turn, further problems. We are delighted that Herodotus, who provided that best of guide-books, has once more deserved his reputation—has once more been proved to have known what he was talking about—when he described the cave-dwellers in the Libyan hinterland. Round ancient clues of that kind the work of well-known explorers, and a variety of information and experience, has been collected, and with extraordinary ingenuity and fervent enthusiasm has been put together into the story that has been given us to-night. To have found, so far north and in such interesting

geographical and geological surroundings, a group of really impressive rock-paintings is a scientific discovery of the first order in this sphere of exploration. The generic relation of these new rock-paintings with the rock-paintings, on the one hand, in the rock-shelters of Eastern Spain, and, on the other hand, with the cave-drawings of South Africa, is obvious. Even the range of colours—for the use of different colours marks stages of the development of these schools of art—is striking and significant; and here too the paintings overlap one another, judging from the examples shown. I have no doubt that when these records have been studied carefully by specialists, in breeds of cattle and so forth, we may have even more precise information than Dr. Bermann has been able to give us in his first survey to-night.

I should like to ask whether he was able to collect and bring back specimens, though that, of course, is difficult. I remember a French pre-historian in South Africa being taken out for a single day near Kimberley and collecting about a ton of really interesting specimens. There was however only one ordinary touring car available, and the greater part of that ton of specimens had to be retrieved by railway lorry on a subsequent occasion.

I should like also to know a little about the types of those stone implements which Dr. Bermann has mentioned; whether the expedition was able to bring back, at all events fragments—and here fragments are almost as good as a complete vessel—of those stone-jars which are one of the most interesting contributions this piece of work has brought us. It was not possible at first sight when the specimens were shown on the screen to identify their origin at all precisely, but I have very little doubt that when necks and handles are brought back to Cairo, still more if they are brought to the museums of Europe, we shall have a large mass of comparable material, and either from the forms or from the actual composition of the clay we may be able to find out where those pots were made. That is a suggestion only; most probably Dr. Bermann, though he has the material, has reserved it for another occasion.

The PRESIDENT: Miss Caton-Thompson has been on this platform before and has done much for the Faiyum and Libyan Desert.

Miss CATON-THOMPSON: I thank you for giving me this opportunity of saying how interested I have been in Dr. Bermann's and Wing-Commander Penderel's great piece of exploration, which they have most admirably described this evening.

I confess I am a little in the position of a distinguished scientist of the Natural History Museum who, when he was asked recently to state the official view about the Loch Ness monster replied: "We deal with specimens and not with theories." I am an archaeologist, and archaeologists deal with specimens and not with theories. Therefore I hope that some specimens have been brought back, either to this country or to Dr. Bermann's country, where they can be examined. When great dumps of pottery, which are not uncommon over parts of the Libyan Desert, are discovered, there is a tendency to conclude that they indicate comparatively late caravan trade movements in the desert, somewhere in the Roman, Ptolemaic, or at earliest the Persian periods. I am not at all sure that is always the case. I know dumps containing 300 or 400 of these great amphorae which are undoubtedly of Roman or Ptolemaic age. But I think it is becoming more and more apparent that the ancient Egyptians also went far out into the desert in search of some of those beautiful rocks with which they made certain of their stone vessels. There was a striking example of that the winter before last, when, in the Western Nubian Desert, a new source for particular varieties of diorite was quite accidentally discovered. That quarry dates back to the Old Empire of the third millennium. I am interested in that discovery because we have, I

believe, found in the Faiyum Desert fragments of the rock brought from that quarry over 500 miles distant. Our specimens are being analysed in Cairo, but there is no doubt, it seems to me, that they came from that distant Nubian quarry. To return to the photographs shown to-night, and to Pottery Hill, discovered by Dr. John Ball and Prince Kemal el Din. The photographs of those jars do not suggest anything very late, but I have never seen or handled one. The form looks interesting, and recalls a certain shape of the earliest Egyptian dynasties. On the other hand, I am told that some of them bear pot-marks which are believed to be Tebu camel-brands. If that is so, it should settle, within certain limits, the age of the pots.

With regard to the rock-paintings, it is interesting to find a group, that is clearly allied to the Eastern Spanish group, so far east as 'Uweinat. Respecting the dating of the engravings, I would suggest that these later groups, which so often contain representations of oxen, either long-horned or, less frequently, short-horned—nearly always portrayed in that curious way with the horns seen full view—are sometimes too readily supposed to denote datable links with Protodynastic and later Egyptian art. Undoubtedly the ancient Egyptians in the very earliest historical period had *both* long-horned and short-horned oxen: that has recently been definitely established. Experts working on Prince Kemal el Din's photographs divided the 'Uweinat rock-pictures into four main groups and suggested that the oldest (with which must now be classed Dr. Bermann's recently discovered paintings) belonged to the late Palaeolithic Age, whilst the two later groups may be equated respectively with the Old and Middle Kingdoms of Egypt. In so far as that sequence is based on the evidence of long- or short-horned cattle I think it is a dangerous assumption to make.

Professor F. L. GRIFFITH (Emeritus Professor of Egyptology, University of Oxford): I am extremely grateful to Professor Myres for having suggested that I should be permitted to attend this meeting. It is interesting to me that the discoveries made on the expedition about which we have heard this evening supplement those made by another expedition during the past year by Major Bagnold who, with Dr. K. S. Sandford, of Oxford, has already explained to the Society the significance of their finds. He seemed to have ascertained that the desert to the west of the Nile was in early Palaeolithic times well watered, and supported a considerable population, and that that population developed a civilization of its own. The inhabitants were divided up into sections, separated from each other by considerable areas of dry sand, but the amount of habitable land lying to the west of the Nile was then very large. The rainfall left its traces in the conformation of the sand-dunes, but it gradually diminished and the area that was habitable likewise diminished. The crowded and unfortunate dwellers in these oases must have perished in a most miserable way, not having camels to transport them through long distances over the sand to the Nile Valley or to the remaining bits of habitable land. Certain traces of human occupation remain, and in spite of the remarkable discoveries of Miss Caton-Thompson, which tend to show that after the prehistoric ages, until the Romans brought into use the practice of making artesian wells, the oases were unsuitable for human occupation, it cannot be denied that the Libyan Desert was inhabited by people whom the Egyptians called Lebu or Libyans and by other names, and actual documents survive to our day which show evidence of habitation of the Dakhla Oasis in the ninth or eighth century B.C.

Abu Ballas—if that is the right name—"the father of water-jars," is an extraordinarily interesting mass of pots. I am not quite sure whether I understood rightly when I took Dr. Bermann to say that he considered those pots to have been made of stone. I looked very carefully at the photographs, particularly the

one complete specimen (perhaps from another site) in the hands of the local governor, and it appeared to me indistinguishable in fabric from present-day ballasses (*belâlês* is the Arabic plural) from which, I suppose, Prince Kemal el Din derived the name Abu Ballas. At the present day there is a large village in the region south of Asyut called Ballas, and that is the great centre of the production of the well-known ballasses or water-jars which are so often seen on the banks of the river and carried by women on their heads, when filled with water. These are of a buff pottery, well burnt and hard, and showing the marks of the potter's wheel. It seemed to me that I could recognize, especially in the large photograph, the marks of the potter's wheel, and the jar must have been made not of stone but of pottery. The type is very similar, on the whole, to the present-day ballâṣ. It has two small ears or handles to carry it by, not the great handles of the classical amphorae, but comparatively small handles which are used in lifting the jar. After a woman has filled her jar with water she gets another woman to take hold of one of the handles while she takes the other, and between them they lift up the jar on to the head of the first woman. I venture to differ from Miss Caton-Thompson in regard to the age of this vessel. It seems to me to belong to a very late period, not much earlier than the last century B.C., and most probably of Moslem age. Its shape is not quite that of the present-day ballas, which is very broad, so that the breadth at the base enables the woman to carry the heavy jar, weighing over 50 lb., full of water, on her head with safety.

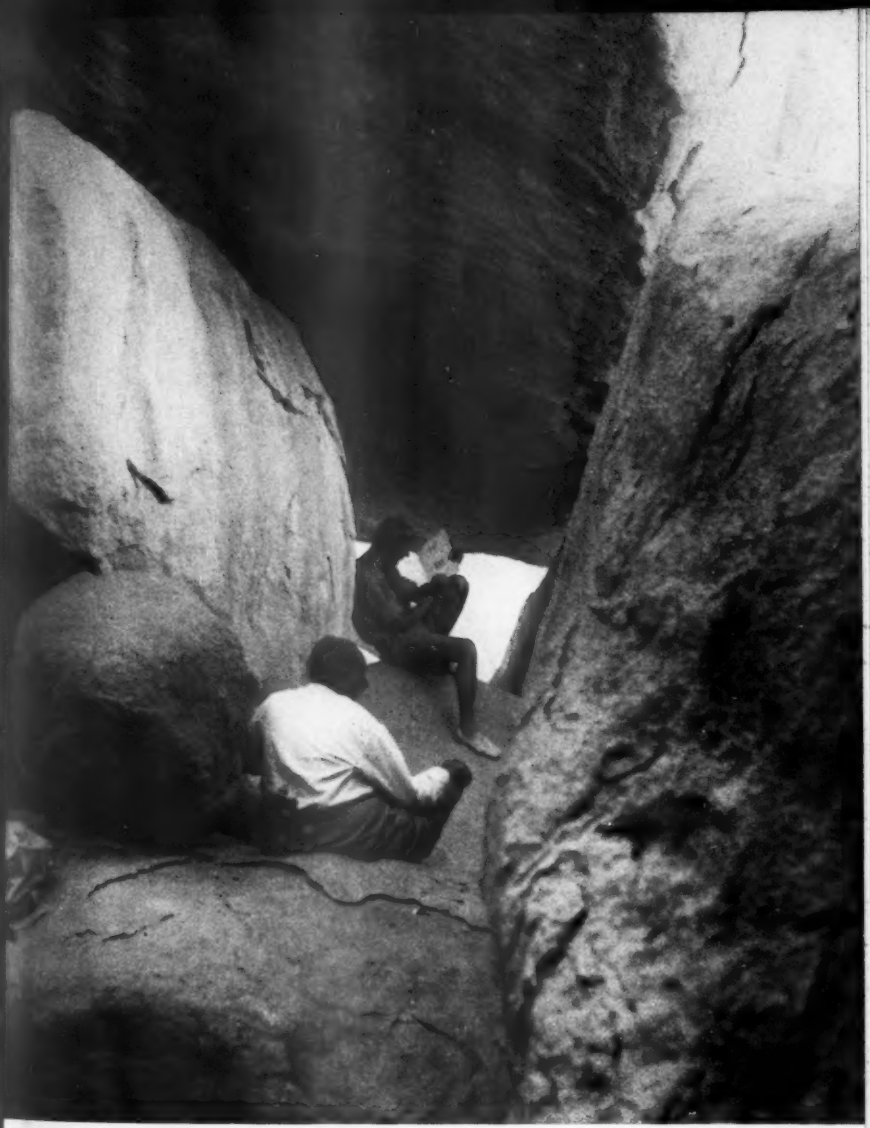
Professor Myres has spoken as an authority on Herodotus, and Miss Caton-Thompson knows the geology and antiquities of the Libyan Desert and the Faiyum, so there is now nothing more for me to say.

Lieut. ORDE WINGATE: My own contribution to the problem of Zerzura is slight and purely negative in character, I did not place it in the Southern desert, where Dr. Bermann has placed it. I based my view on its locality on information obtained from Colonel de Lancey Forth, Prince Kemal el Din, Newbold, and other explorers. Any one who has travelled in the oases surrounding the Libyan Desert will realize that the legend of Zerzura is as vague as it is universal, and you can get some one to tell you that Zerzura is in practically any area in central Africa. I do not think that the weight of the evidence is, even now, in favour of any particular portion of the Libyan Desert. What Herodotus says about the land of the troglodytes is not in reference to "Zerzura," a legend of a different and later origin, and it may or may not refer to the same place.

In Kufara there has been a legend of Zerzura for many years. I was told by some of the Zuweia that Zerzura lay in the centre of the sand sea, and my own expedition was designed to verify this. I started from Bir Abu Mungar with a few Arabs and camels, and pushed out west into the desert. I reached a point on the frontier that is definitely on the western verge of the sand sea. This was confirmed by Clayton, whom I met almost miraculously, on my way back to Mungar. A comparison of our findings showed that no useful purpose would be served by a second journey in this region. I decided therefore to follow some ancient tracks I had encountered leading in the direction of Regenfeld. On this second march I was fortunate in finding a number of Mousterian palaeoliths, much evidence of bird migration, etc. It was in this area that I found a depression resembling closely that of a dewpond. Near by were hearths and flint instruments.

I should like to congratulate Dr. Bermann and his companions on their discoveries; and I would especially urge that a British expedition be equipped to visit the Gilf in the near future, as I feel convinced that much more of the greatest scientific interest awaits the explorer of that still uncharted area.

The PRESIDENT: I know it is very late, but this is one of the most important



Phot. Hans Caspa

Count de Almásy copying the rock paintings: Dr. Bermann in the foreground

Phot. Hans Ca

The first view of Wadi Talh

meetings we have had. Dr. SANDFORD, who was to have been here to-night, asked that this short paragraph be read: "It is a pleasure to have an opportunity of congratulating Count Almásy and Squadron-Leader Penderel on the latest of their successful journeys in the Libyan Desert. A little over a year ago I had the good fortune of visiting the volcanic field discovered during an earlier flight between the 'Uweinat massif and the Gilf Kebir: we found it on the ground by following directions given me by Clayton, who took part in the earlier aerial reconnaissance. Photographs taken from the air on that occasion, some of which appeared in the *Illustrated London News*, can now be identified with certain parts of the field that we examined in some detail. Ground and air photographs combine to make a remarkably complete picture of the new field.

"In 1932 the motor-car expedition led by Bagnold, and two aeroplanes piloted by Penderel and the Earl of Brandon, though totally independent organizations, gave one another mutual support at intervals. Finally they became united for one memorable night at Gebel Kissu, after a chance meeting between Penderel's aeroplane and our single car on its way from the volcanic field to 'Uweinat a day or so earlier. Thus Penderel, Shaw, and I had an opportunity of discussing some problems of geological and archaeological observation from the air, with the ground and its problems actually before us. The flights had already shown that many features of scientific importance can be discovered in a few hours' reconnaissance from a base established in this remote corner of the desert. Some of the features explain their nature by their shape: others demand that they should be walked over before they can become more than tantalizing objects in a photograph; both classes need to be marked on a map when under observation from the air, or in these wide spaces they will be lost. This is a serious difficulty not yet overcome, but Penderel and Almásy have earned our admiration and gratitude by combining with their flights more landings and footwork than many pilots would attempt on such variable ground and so far from home.

"As Zerzura fades away into the realm of legend once more, why should we not start a new search which might add historical interest to legitimate exploration? Why not an aerial search for Cambyses' lost army? We have our Zerzura Club; why not a Cambyses Club?"

Dr. BERMANN: I should like to reply to a few of the questions. The jars or pots were not stone; they were earthen. The photographs did not make the position clear. There are two different shapes at least, one slender, the other broad. On the slender ones were signs which I am told indicate the property of the Tebu or other Western tribes. I have seen such jars in Kharga. We actually brought home a few of those jars. Ours are now in Cairo where they will be shown in the future Desert Institute. We were also fortunate in collecting many stone implements of different types. Those found in the Cave of the Giraffes, as I call it, were flint and other hard stones, but mostly flint, and the arrow-heads were also flint. What we found in 'Uweinat were very sharp obsidian implements and distinct in form from the others. I understand from letters from Almásy that the recent expedition has found many implements. The specimens collected by us and sent to the Budapest University will be classified. We found in the Giraffe Cave the bones of a large mammal, probably a dog, which must have belonged to the people.

As to the name "Zerzura" our Tebu friend, Ibrahim, asked where Zerzura lay, said: "Oh, those silly Arab people, they do not know anything; they call these three wadis in the Gilf Zerzura, but we local people know their real names."

I cannot conclude without thanking the President and the members of the Society, who can hardly realize how great the prestige of this Society is all over the world, especially on the continent, and how much I am honoured by the

privilege of being here. And finally, I desire to thank H.E. the Minister of my own country.

The PRESIDENT: It remains for me to bring the proceedings to a close, and I am sure you will agree that this has been a most important and an extraordinarily interesting evening. I am also sure that Dr. Bermann's infectious enthusiasm and humour must have been imparted to you during his lecture. We thank Commander Penderel and Dr. Bermann for jointly, and at very short notice, coming here and giving us a most important discourse upon an interesting subject which seems to me to open the door to a vast store of possible interest for many explorers for many years to come. I beg you to join me in thanking them heartily for their very fine lecture.

A STUDY OF THE SAND SEA IN THE LIBYAN DESERT

DR. LADISLAS KÁDÁR

THE characteristic long sand-dunes of the Libyan Desert were made well known in the last few years through the works of Dr. John Ball ("Problems of the Libyan Desert," *Geogr. J.*, vol. 70, pp. 21, 105, 209), of Prince Kemal el Din Hussein ("L'exploration du Desert Libyque," *La Géographie*, L, 1928, pp. 171, 320), of Major R. A. Bagnold ("Journeys in the Libyan Desert, 1929 and 1930," *Geogr. J.*, vol. 78, p. 13; and "A Further Journey through the Libyan Desert," *Geogr. J.*, vol. 82, pp. 103, 211), and recently through Lodovico di Caporiacco ("Osservazioni sul Deserto Libico," *L'Universo*, XV, 1934, p. 9). Dr. John Ball and Major R. A. Bagnold found that their direction is parallel with the prevailing winds. Caporiacco, who was in Libya contemporaneously with us, confutes the hypothesis on the evolution of dunes as evolved in the book 'Das Gesetz der Wüstenbildung,' by Johannes Walther, because it is impossible to explain with the aid of said hypothesis the characteristic sand formations of the Libyan Desert. Three months before the publication of Caporiacco's essay, on 12 October 1933, without, of course, knowing of Caporiacco's work, I, in my account of our expedition as delivered before the Hungarian Geographical Society, have stated the inaccuracy of Walther's hypothesis. Since my argumentation is not identical with that of Caporiacco, and because I do not think his hypothesis acceptable, in the few following lines I try to give an account of the whole matter.

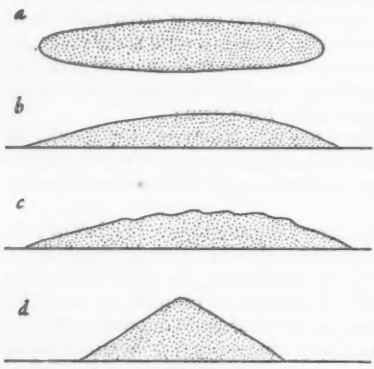


Fig. 1

We have to make a close examination of these Libyan dunes, called by Major

Bagnold *seif* dunes. The ground-plan of those dunes is in shape of an oval (Fig. 1 (*a*)), which is the more slender the longer the dunes are. The transverse section is usually an isosceles triangle (*d*), the longitudinal section has the form of an elongated bow, mildly sloping on the windward side and rather steep on the lee side (*b*). Such uninterrupted forms are however rare. Small barchans are not unfrequently placed on top of these dunes and they make its silhouette resemble waves (*c*). Such freely drifting sand has not yet been described on any part of the globe, so, for convenience sake, we may call them *Libyan Dunes*, because I have not heard any characteristic name from the mouths of the natives of Libya.

The longitudinal axis of the Libyan dunes, northward from the middle part of the Gilf Kebir, is always directed north-north-west and south-south-east (azimuth 165° to 175°), because, as we shall see, the prevailing winds have also the same direction. The length of these dunes may extend from a couple of hundred metres to many kilometres. The longest I could trace to its end was 140 km. long. There does not exist, to my knowledge, a dune of greater uninterrupted length. One of its neighbours is 57 km. long, but there are also several 1–2 km. long. Their height varies with their length, but generally 30–40 metres, though there exist also a few about 100 metres high. The regular Libyan dunes sit close on the soil and their edges are sharply separated through their yellow sand from the black-brown pebbles of the soil.

It is a characteristic feature of the Libyan dunes that they can always be found in parallel lines with the direction of the prevailing winds. Between them the soil is left bare several kilometres wide. Seldom are they forced together so close that their interior sides meet, but then, naturally, this interior side is higher than their exterior side, being filled up with sand.

H. J. Llewellyn Beadnell conducted regular observations of wind in Kharga, from April 1907 to March 1908. During this time he observed among 337 windy days 281 with north wind, 22 with south wind, and 34 with winds from other directions. Of the winds which carried sand 103 came from the north, 12 from south, and 6 from other directions ("The Sand-dunes of the Libyan Desert," *Geogr. J.*, vol. 35, 1910, p. 385).

During our expedition I made three times daily an observation of the direction of the wind. Eighty-four of my observations belong to this geographical latitude and can be classified as follows:

Direction ..	N	NE	E	SE	S	SW	W	NW	*Total*
No. of winds	53	5	4	1	12	0	1	8	84
Percentage of winds ..	63·1	5·9	4·7	1·1	14·2	0	1·1	9·9	100

From this we may see that north winds are greatly prevailing (63 per cent.) and the direction of these north winds is identical with that of the dune rows. There is however a difference of about 10 degrees which is due to the lack of appropriate instruments in observing the directions of winds. My instruments gave only eight points of the compass. Next to this in frequency is the south wind (14 per cent.), the direction of which is again identical with that of the dunes, though, as it is in counter direction to the former, it does not twist their course, but only stops and delays their procession. Besides these we mention

only the north-west wind with its frequency of 10 per cent., but this does not differ much from the direction of the dunes. Of the strong winds north was 4 and north-west was 1; in this latitude I have not observed strong winds from any other direction. It is true that these facts are fruits of observation only a month and a half long, but they are still sufficient to reinforce the statements of my predecessors and to prove that the Libyan dunes are parallel with the prevailing wind.

Before the sand-world of the Libyan Desert was thoroughly and scientifically explored we have not heard of dunes which are parallel with the prevailing wind. Therefore reports regarding these dunes were not taken seriously, as was the case with the discoveries of Rohlfs.

Johannes Walther, in his invaluable 'Das Gesetz der Wüstenbildung' (1924), in accordance with the best authorities, has pointed to the barchan as the shape for freely drifting sand when it comes to rest on the plains. The barchan is a crescent or horseshoe-shaped dune, the windward side of which is sloping and convex, the lee side concave with the sand standing at the maximum slope (32° to 33·5°). Its two sides extend forward like two lowering and slendering horns. The windward slope I found 5° to 6°, the sides 10°, the steep part 33·5°. Since this type of dunes has been extensively described and is well known, I shall not dwell lengthily on it.

The shape of a barchan may be changed only in so far as two or more dunes may join to form a twin-barchan. Walther has heard of the oblong dunes of the Libyan Desert and has even seen the Abu Moharik dune, the Kharga-barchans of which he found undoubtedly wandering from the north to the south. But near Bahr el Uah the barchans can be found mixed with oval-shaped, typically Libyan dunes. Walther thought that these dunes could not be transformed into barchans on account of local winds. But this statement contains contradiction, because if local winds hinder the development of a group of dunes, then no barchans should be found in the group, though there are in fact more. Thus the theory of Walther must be supplemented because it cannot explain the origin of longitudinal dunes.

Mr. W. J. Harding King exposed in Kharga, during a sandstorm, a bucketful of sand to the wind. He poured it out at every occasion in a different shape on a flat iron plate. The wind at once attacked the sand-mass, shaping it either like the letter D, *i.e.* in the form of a primitive barchan, or piled it up in the shape of a cigar. He could never be quite sure beforehand as to what shape it would put on, because this did not depend either on the quantity of the sand, or on its original form, or on the strength of the wind (*Geogr. J.*, vol. 51, 1918, pp. 29–30). This interesting little experiment proves that the shape of freely drifting sand may be both like a cigar or a barchan. But the same fact is proved by the existence of all the dunes of the Libyan Desert.

It very often happens that a long line of dunes is broken up and continues in barchans at its lower, southern end. I cannot however mention any example of barchans closing together into a dune. The speed of the movement of the longitudinal dunes has, to my knowledge, not been measured as yet, as was done with the Khargan barchans by Mr. H. J. L. Beadnell, who found a yearly average of about 15 metres. I surmise however that the more voluminous Libyan dunes move with less speed and that is the reason why on top of them

small barchans are liable to be formed and why the loose sand of the dune-end takes the shape of barchans.

Dr. Jenö Cholnoky, in his fundamentally important "A futóhomok mozgásának törvényei" ("The Laws of the Movements of Drifting Sand," *Földtani Közlemények*, 1902), and in his book entitled 'Morfológia,' defines dunes as "ridges of drifting sand crossing the direction of the wind." Their windward side is a normal slope, the lee side is the maximum slope afforded by the sand. Dunes, says Cholnoky, develop only from shore-dunes, and only in places where they cross the direction of winds, and remain there only if their area is constantly swept by two winds of contrary directions, otherwise they break up into barchans ('Morfológia,' pp. 177–178).

These dunes of Cholnoky are not identical with the Libyan dunes, which are longitudinal, because while those cross the direction of the winds, these are parallel with it, and while those are temporary forms connected with the shore-dunes, the shape of these is constant even if they are formed somewhere far from the original birthplace of their sand. The cross-section of the dunes described by Cholnoky is like the longitudinal section of barchans, the cross-section of the Libyan dunes is triangular.

The sides of dunes, the back and the wings of the barchans are covered with ripple-marks. Ripple-marks can be found very often independently on any sandy soil. Sometimes they cover very large areas. Their height varies from 1 or 2 cm. to about 50 cm. Their shapes are very varied, but their direction always crosses that of the wind. Once I saw a group of 50-cm.-high ripple-marks which consisted entirely of ripple-marks resembling barchans, their ends projecting horn-like forwards. It is not quite impossible that ripple-marks directly transform into barchans, but I am not quite sure of that, since I have not found a sufficient amount of transitory stages to prove my thesis satisfactorily.

Mr. Harding King has watched the evolution of a barchan in Kharga. The soil was originally full of ripple-marks slowly growing into primitive whale-back dunes and eventually developing into barchans (*Geogr. J.*, vol. 51, 1918, p. 24). Based on his researches conducted near Buchara, J. Walther reconstructs (*op. cit.*, p. 272) the development of barchans in the same way. I do not know why sand is occasionally forced to gather into whale-back dunes on ripple-marked soil. One can see innumerable times a rippled sand-surface without the faintest sign of developing dunes. It is sure however that ripple-marks always precede the development of dunes.

Two or three kilometres north from Abu Ballas I found yellow streaks of sand stretching sporadically north-north-west to south-south-east on grey serrir soil. Their ground-plan was in shape of an oval, their length 5–6 metres on the average, and about 1 metre broad. They were all ripple-marked in east-west direction, or rather east-north-east to west-south-west. Apart from the ripple-marks the different-coloured streaks did not rise above the level of the ground. I presume these dunes are *in statu nascendi*, and so sooner or later all these colour-spots, retaining their oval shape, will develop into crested dunes. Unfortunately I could not find dunes in a more advanced state of development. Di Caporiacco has found however, near Garet Cudil and Gara Zueja, small dunes several metres long and half a metre tall, scattered in

sufficiently broad rows. Their shape and profile was that of the larger dunes. Di Caporiacco has declared them to be dunes in the state of development, and this is very likely.

The process of the development and growth of dunes is still unknown to us, but the above-mentioned experiment of Mr. Harding King makes us think that the process is like the growth of barchans.

On 31 March 1933, in our camp near Abu Ballas, we had a great sandstorm with north wind. After it we found all our gasoline tanks surrounded with sand in the following way: On the windy side there could be found an about 10-cm.-tall semicircular sand-dam (see the photograph 1). On the spot protected from the wind there could be found a tiny sand-hill of about the same altitude and triangular both in its ground-plan and cross-section. This fact I explain in the following way: The wind rises before the obstacle (Fig. 2 (*a*)) but drops the great part of the sand carried with it, and this sand is stored in the places which are protected from the wind, as I have indicated with dots on the sketch. But at the same time the wind evades the obstacle also on its sides, not only above (Fig. 2 (*b*)), and thus gives a crescent shape to the sand-hill which is piled up before the obstacle. Beyond it the two arms of the wind join again, but there remains between them a triangular calm spot. The sand which got into this place stays there forming a hilly stretch. In its final stage of development it is as tall as the obstacle itself and fills up the entire space that is dotted on the first sketch. There arose a crescent-shaped dam even behind our tents which turned their backs on the wind, but I could not find the sandy hill stretch on the calm spot before the tents. The reason of this may be that the doors of the tents were left open, and so the sand-hill could find no footing, or basis, which is always necessary for its formation.

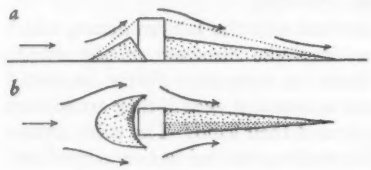


Fig. 2

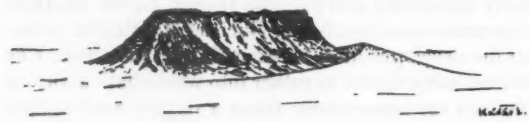


Fig. 3. Sketch of hill and sand-dam.

Such a process has been described by Cholnoky also, who observed it from the door of a Chinese temple and in the Hungarian drifting-sand area, where such sand-hills can be found behind bushes (see his "A futóhomok mozgásának törvényei," *Földtani Közlemények*, 1902).

I find it necessary to dwell at length on this aspect of the question, since this fact plays a great part in the Libyan Desert, and has not been described yet as far as I am able to ascertain. All the outliers serve as hindrances to the wind both on the desert-level and on the Gilf plateau. The phenomenon occurs very often in true proportion with the size of the obstacle. Mount Abu Ballas is surrounded by a 2–3-metre-high sand-dam on its north side. On top of the Gilf Kebir I have found one which was 8 metres high. Di Caporiacco describes in his often-quoted book (p. 10) the growth of such a crescent dune,

but I am afraid he does not distinguish it sufficiently clearly from barchans which cannot be found around the Kufara oasis.

Such sand-hills can frequently be found on the south side of mountains and hills in and around the Sand Sea; some are provided even with three or four sand-hills or tail-dunes, stretching on and away. Major Bagnold describes them as sand-drifts or sand-shadows ("A Further Journey through the Libyan Desert," *Geogr. J.*, vol. 82, p. 121). These sand drifts resemble very much the freely shifting long dunes, especially as regards their cross-section, which generally is an isosceles triangle, the declivity of which is the same as that of the Libyan dunes, usually 13 degrees. Their longitudinal sections are however fundamentally different: barchans can never be found on the crests of tail-dunes; the Libyan dunes rise slowly on their windward side, reaching their maximum height a little beyond the middle, and then the slope begins again. The tail-dune is highest at its starting-point, and from there the slope stretches evenly till the end. The fully developed tail-dune is as tall as the hill itself. The tallest I saw was 126 metres high, attached to the farthest north-east rampart of the Gilf Kebir. There were two of them, one 7, and the other 12 km. long. The average height of dune-rows was only 40 metres in the same area. Tail-dunes may thus be much taller than the dunes near by. Their length too is fixed. Their sides are rather hard, and can be walked on; it is very convenient to walk to the top of a hill by them, and this is very often the only means of getting up. On the west side of the Gilf there is a camel-trail leading to Wadi Abd el Malik across the plateau, and this trail ascends the Gilf on a tail-dune.

Fig. 4

It is very important to notice that neither the tail-dunes nor the sand-dams are moving formations of sand like the barchans and the crested dunes. They remain in the same place; sand stops and rests in them because they are in calm spots. This situation is disturbed and changed by a wind of different direction, which brings the grains of sand into motion.

Furthermore it is important to note that the tail-dunes show, through the story of their development, the precise direction of the prevailing wind, as did the barchans. If we had no other proof at all we could prove even with the aid of these two sand formations that the crested dunes are parallel with the prevailing wind because they are parallel with the tail-dunes and because the barchans into which they dissolve are also products of such winds.

There is plenty of sand everywhere in the desert. Once we were in a high wind on a perfectly flat piece of desert. Though there were no dunes near us we still found the air so full of sand that we had to hide our faces behind a cover. One could see the sand almost galloping over the surface of the soil in long parallel streaks as the wind beat upon the soil. This was the reason why we found those blurred parallel streaks on the *serrir*, which can easily be mistaken for caravan-trails.

Now we have to examine how a wind of another direction influences the dunes. The influence on barchans of a wind coming on the same line but in

the opposite sense was described for a Murghab example by J. Walther (*op. cit.*, p. 274), by J. Cholnoky ('Morfológia,' p. 177), and by Harding King, ("Study of a Dune Belt," *Geogr. J.*, vol. 51, 1918, p. 25). The wind throws the sand of the steep side on to the more sloping one, building a wreath there. The old steep slope becomes more and more sloping and its arms shorter, and when the wreath reaches the foot of the barchan then the whole barchan turns, or rather is turned. The same happens with the Libyan dunes if the wind switches into the contrary direction.

I had a chance to watch the changing of a tail-dune on 30 March 1933. The azimuth of the dune was 170 degrees; we had a sandstorm on the same day with west (267 degrees) wind. Thus its direction was almost at right angles to the tail-dune. The wind, carrying a lot of sand, ran up the slope of the dune setting every grain of sand on its surface in motion. As the wind reached the crest it swept away the particles of sand which it carried thus far with it, and so the crest looked as if smoking. But the heavier grains of sand, which it could only toss up with jerks and jumps on to the crest, fell off beyond the crest and stayed there where they had fallen. Thus the crest moves more and more eastward, and the wreath becomes enlarged and grows through the heavy grains of sand which fell off the crest. The air is filled with sand, the fog is so thick that my shadow appears on it. It was curious to observe within it my smaller shadow on the soil. One can very well observe the movements of this air coloured with the sand: it whirls back at the east foot of the dune. This is however far from the point where the steep wreath originates, neither has it a role in its development.

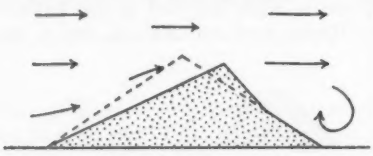


Fig. 5

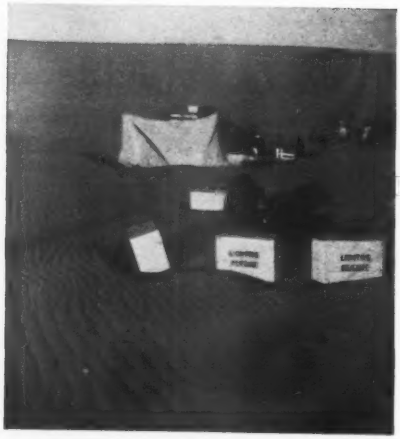
The slopes of the tail-dune were 13 degrees before that. Now the west wind modified this windward slope to 10 degrees. The lee side did not change, its line is broken by the 33·5 degree slope of the wreath or collapsing front. Both sides were ripple-marked in right angle to the axis. The ripple-marks of the western side grew and their direction changed 90 degrees at right angles to the wind. The ripple-marks remained in their places on the east side, but with the sand falling on them from the air they were quite blurred. The north-west wind started at noon and stopped at 6 o'clock p.m. During these six hours there was piled up on the eastern slope of the dune a "wreath" about 1 metre high and with a very steep side. The originally almost straight crest of the about 1-km.-long dune was somewhat disturbed: in some places where the crest was not so high it leaned more to the east. If the wind had lasted, it would in all probability have broken up the tail-dune into barchans. But its work was interrupted and the process left unfinished.

While I was near or amidst Libyan dunes I did not experience a side wind sufficiently strong to influence the dunes. But when after an absence of two weeks I got back to our camp, which was at the north-eastern corner of the Gilf Kebir, I found the dune completely altered. On its more or less broad back, when I left the camp, a fortnight before, there were small and sometimes quite regular barchans, turning their steep side to the south. Between them the

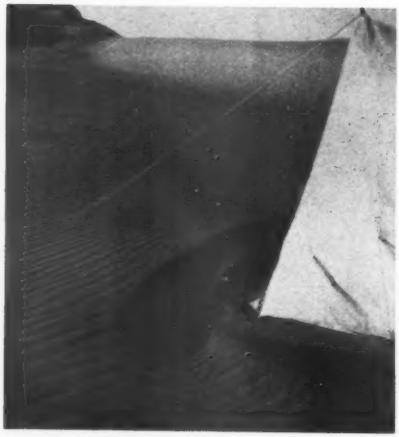
Desert sand ripples, near Chianti Camp

One of the Abu Ballas jars

Phots. Hans Casparius



Petrol cases after a sand-storm



Sand-dam caused by a tent during a sand-storm

Phots. Dr. Kádár

Looking north over a dune-line from the plateau of the Gilf Kebir

crest of the dune was comparatively intact in the north–south direction. Now, after my return, undeveloped and irregularly developed barchans were placed on the western slope, the very steep slope of which looked south-east. The crest-line was sharp but broken innumerable times and curved. On the east side it had a wreath with the maximum slope. All this seemed clearly to prove that in my absence there had been a strong westerly or north-westerly wind which had troubled the dune.

So we may see that the side wind piles up a wreath on the lee side of the dune. This was observed by Prince Kemal el Din Hussein, and was described by him without trying to give an explanation (*La Géographie*, 1928, I, 335). L. di Caporiacco has obtained the same results and declared that "this side where the dune appears steep, changes with the change of the prevailing wind." He tried to explain this process theoretically in the case of two winds which meet in an acute angle (*L'Universo*, 1934, p. 12). I find it necessary to notice here that whatever direction is followed by the wind, it easily changes the shape of the dune.

The next problem is what happens to the different dune-formations when there is a change in the prevailing direction of the wind which brings them into existence. The answer is very simple: the dunes have the same shape, but the direction of growth follows that of the wind. This is the case equally with the Libyan dunes, the barchans, the tail-dunes, and with the sand-dams as well. If this change of the wind's direction is sudden, then the Libyan dune does not undergo a break at the spot where it changes its course, it only curves, and turns its head into the new direction. This is the case in lat. 24° on the eastern edge of the Gilf Kebir where a south-west to north-east valley opens, cutting the plateau in two. There the heads of the dunes turn toward the south-west. In the valley numerous tail-dunes may be found, directed south-west; here there is local divergence of the north wind caused by the steep rim of the Gilf's southern part. Major Bagnold writes that all the dunes lying north of the Ammonite mountains turn their heads eastward. I cannot supply an explanation in this case.

The north-north-west wind which generally prevails in the Libyan Desert stops at lat. 23°. The direction of this wind is identical with that of the winds of the eastern basin of the Mediterranean, as if continuing them. Below lat. 23° the north-north-east direction of the dunes changes to south-south-west quite suddenly. This sudden change can be observed also in Cyrenaica, west of the Gilf Kebir but in lat. 24°. The more south we go the greater the deviation of the dune-lines to the west. The change of direction is in some cases quite apparent, as, for example, 50 km. west from 'Uweinat where the dunes change 20 degrees toward west. Prince Kemal el Din attributed this fact to the current of air which arises west of the 'Uweinat mountains (*La Géographie*, 1928, I, 334). This is however not very likely, since the phenomenon may be observed also east of 'Uweinat. It is more probable that this partly sudden, partly gradual deviation to the west of the prevailing wind is a general phenomenon proceeding from the north to the south. Major Bagnold writes: "All the dunes conform in direction to a . . . clockwise rotation. . . . The dune direction . . . is that of the prevailing wind also." And this wind is to my mind a *passat*-wind.

We do not know as yet of any other area with drifting sand like that of the Libyan dunes. There are however striking resemblances to some of the Hungarian drifting sand areas, judging from the map. These too consist of ridges and valleys parallel with the prevailing wind. But there is a characteristic difference in that the moister climate and the afforestation planned and executed for centuries have bound and fixed all those sandhills. They can be attacked by the wind only in a few spots, and starting from these long furrows are drawn in the sand, the nature of which was described and discussed by J. Cholnoky ("A futóhomok mozgásának törvényei," *Földtani Közlemények*, 1902), by Dr. Gábor Strömpl, and by me (Dr. G. Strompl, "Budapest környékének futóhomok-területeiröl," *Földr. Közl.*, 1912; L. Kádár, "Fizikai földrajzimegfigyelések Újpest Környekén").

Cholnoky, in whose time the Libyan dunes were as yet unknown, had tried to explain and derive these sandhills and flats from the shore-dunes. According to him these shore dunes dissolved and broke up into barchans and thus proceeded until finally, through the fixing and binding of the sand, there were left no other shapes but the remains of crests, and furrows drawn by deflation-winds. On account of the conspicuous resemblance of the Hungarian sandhills and the Libyan dunes I think that once the prevailing sand formations of the Hungarian drifting-sand area were also Libyan dunes.

SCOLT HEAD ISLAND: *A paper read at the Afternoon Meeting of the Society on 12 March 1934, by*

J. A. STEERS

SCOLT HEAD ISLAND is a National Trust property on the north Norfolk coast between Burnham Overy Staithe and Brancaster. In outline it is very irregular, and its greatest length from the Far Point to Burnham Harbour, measured along the foreshore, is about 4 miles. The width varies with the height of the tide. As only occasional tides reach the inner foot of the main ridge of dunes, a greater or less part of the saltings is usually exposed, and forms temporary dry land.

There is, in fact, often no true island at low tides. Norton Creek, separating the island from the mainland, dries out in certain parts. This channel however forms the real boundary of the island, although some shingle ridges lying to the south of it may be considered as an integral part of the structure of the island complex. The inner edge of the marshes follows fairly closely the main coast road, and the change of slope from the flat marshlands, natural or reclaimed, can easily be traced. The river Burn flows into the marshes at Overy Staithe, and its waters reach the sea through Burnham Harbour. From this point eastwards as far as Wells there are extensive reclaimed marshlands which now form valuable grazing land.

The sand-dunes east of Burnham Harbour were formerly regarded as continuous with those of the island, and the harbour was assumed to be a relatively recent formation (1). These easterly dunes run as an unbroken range to Holkham Gap, and then another line runs in arc-form as far as Wells. One object of the present paper is to give an account of recent work on the island which suggests that Burnham Harbour is an original opening.

Although separated from the island by Brancaster Harbour, the dunes and ridges composing Brancaster Golf Course must be taken into account. These ridges, unlike those of the island, but like those south of Norton Creek, have grown to the eastward. In recent years several new ridges have been built at the eastern end of the Golf Course. This accretion has been balanced by rather severe erosion near the Club House.

Anticipating the account of the evolution of the island, it may be stated here that it shows a marked tendency to westward growth. Hence structures near its western end are newer than those farther east. A glance at the map will show that the island consists of a main beach with dunes running parallel with the sea, and with a series of shingle ridges, partially dune covered, running landwards from the main ridge. The comparatively great length and relatively wide spacing of these laterals are points of some interest. They all probably represent former terminations of the island. It is significant that the laterals first trend south and west, and then turn through a pronounced angle and run in a direction between south and east. This is very different from the laterals of the Golf Course ridges and also from those lying south of Norton Creek. The contrast can be seen clearly on the map.

The Shingle Ridges and Dunes

Any shingle ridge of the complex is composed almost entirely of flint pebbles mixed with a large proportion of sand (2). Stones, other than flint, are

easily found, but do not form more than about ½ per cent. of the total quantity. The flint pebbles are normally well rounded, but sometimes angular pebbles occur on shingle flats, *e.g.* on the flat opposite Beach Point and south of Norton Creek. Typically, the ridges are long and narrow, but sometimes terminate in flat spreads of shingle. Most of the ridges are stable, but the shingle of the outer ridge is mobile, as is that of the newest ridges near the Far Point, as well as a certain amount on the Long Hills and Golf Links ridges.

Dunes have accumulated on the ridges; they arise partly because of the ridges, but normally they begin to grow around tufts of grasses (mainly *Psamma arenaria* and *Agropyrum junceum*) which take root on the shingle and form obstacles around which the sand can accumulate. All stages of dune development can be seen. New dunes are formed near the Ternery; these gradually unite and form a continuous ridge running from the Ternery to Hut Hills. The sand forming these dunes comes from the extensive flats which are exposed at low water. As newer shingle ridges are always liable to be built in front of the particular ridge upon which dunes are forming, it follows that, once a new ridge is built, the sand supply is cut off from the older ridge, and dune growth thereon arrested.

Some of the laterals, *e.g.* Long Hills and House Hills, carry high and well-developed dunes which must have taken a long time to form. To do so it seems that during the time of their formation there was little or no tendency for newer ridges to form in front of them and so cut off their sand supply. It is not possible to say precisely why this was so. In such formations as Scolt Head Island there is usually a continual struggle between the forces tending to build them longitudinally and those causing them to recurve and form a series of laterals. At certain times one set of forces will prevail over the other (3). In recent years the westward growth of the island has been marked; for some time prior to 1880 this was not so. Probably, then, for a considerable period of time the Long Hills ridge formed the westernmost lateral of the island, and sand-flats lay to the west of it and afforded an ample supply of sand to form the dunes. Similar circumstances presumably accounted for the dunes on Butcher's Beach, Privet Hill, and House Hills.

If the sand supply ceases dunes are liable to suffer erosion. This results from several factors. *Psamma arenaria* never forms a very close turf, and it is characteristic of the plant that when the supply of blown sand ceases, it thrives less well; thus old dunes often carry rather "dead looking" *Psamma* (4). Other plants have usually colonized the dunes when this stage is reached, but patches of sand are always exposed. These exposures may be attacked by the wind, and once such an attack begins, there is no theoretical limit to it until the dune is cut through, or removed altogether. The roots of the *Psamma* and other plants restrict this attack to some extent, and the normal end of erosion is the production of a bell-shaped hollow or "blow-out." Some of these are indicated conventionally on the map. They fall generally into two groups, the one facing the prevalent west and south-west winds, the other the dominant winds between north and east.

Blow-outs may form elsewhere than where bare sand is exposed. Any agent which uncovers the sand is a potential source of unlimited erosion, and the rabbit is a bad offender. If people who shoot rabbits have to dig them out

of their burrows, considerable damage may also ensue. This is one reason for restricting indiscriminate shooting on the island. Some of the larger of these blow-outs have been replanted with *Psamma*. This grass does not spread over the bare sand very rapidly, as it thrives best where the supply of new sand is greatest, a condition not usually found in blow-outs.

The sand-flats exposed at the western end of the island and off the main beach are the chief sources of supply for the dunes. Smugglers' Gap is now filling up with sand from the main beach, and easterly winds carry large supplies to the Norton Hills and the dune range east of Burnham Harbour. Similar flats must at one time have existed to supply the dunes, parts only of which are left, on the ridges south of Norton Creek. On these, and on some of the older of the island ridges, there is only a meagre cover of sandhills. These are relict patches, and clearly indicate a former much greater development of dunes. Areas, such as these, from which sand has been removed by erosion, are characteristically colonized by *Statice binervosa*. House Hills and Hut Hills are perhaps the best examples of closely covered dunes on the island. The former are certainly old dunes, but have not suffered greatly from erosion. Some of the Norton Hills are old, but much new dune has formed in recent years near Burnham Harbour. The finest dune complex occurs east of this harbour but, as it is not on the island, it will not be described in detail.

The Marshes

The shingle and dune ridges divide up the island into segments. The parts between the ridges are filled with salt marshes, whose foundation is generally sand (see p. 483). To illustrate the formation of marshes it is most convenient to describe what is taking place at the western end. Within the Far Point are extensive sand areas on which a thin coating of mud is accreting, a process aided by the colonization of the bare sand by plants, which often first grow in the "pads" of matted seaweed scattered over the flats. Farther east the mud layer increases in thickness and extends in area. The mud may be firm, but, more often, on the newer marshes it is soft and sticky. It is formed of fine particles brought in by the tides and deposited, usually near the turn of the tide, in sheltered places.

With the gradual raising of the marsh-level in this way the problem of drainage is intimately connected. On the newest marshes the tide flows and ebbs as a thin film of water. As the marshes grow higher the mud is deposited rather more easily and thickly in sheltered places, and shallow channels begin to evolve. With the gradual growth of the marsh these channels develop, and in the early parts of the flood and later parts of the ebb the tidal waters become more and more confined to them. This effect is intensified by the spread of vegetation, because the plants increase the speed of sedimentation in that they interfere with the "run" of the water. The marsh therefore grows in height, and the water concentrates still further in the channels. A higher tide spreads all over the marsh, but during early flood and later ebb it is almost entirely confined to the creeks. In course of time the carpet of vegetation spreads, the marsh as a whole grows higher, and the creek system develops. Sand blown on to the marshes increases their height, and it is quite usual to find thin

alternations of mud and sand in a vertical section. This spasmodic deposition of sand is usually more rapid than the slow but continuous deposition of mud.

The marshes gradually increase in height from west to east, *i.e.* from younger to older. This can be clearly seen from one of the higher dunes when a big tide is flooding the marshes; the younger are inundated before the older.

The creeks of the individual marshes all drain eventually to Norton Creek. Hence the lowest part of any marsh should be near this creek, but this is not always the case. The fact that *Obione* (*Atriplex*) *portulacoides* so frequently grows along creek margins leads to greater deposition just near the creeks, so that the inter-creek parts remain rather lower. This increase in ground height is often more apparent than real on account of the thickly growing habit of the *Obione*. Again, in some of the older marshes the level remains practically constant right down to Norton Creek (see Great Obione Fringe on map).

The older marshes all show similar features, so that a description of one will suffice. Plover marsh is hemmed in by two long lateral ridges, flat in cross-section. The shingle of these ridges extends a little way under the marsh, and on the marsh-shingle boundary is a wide spread of *Suaeda fruticosa*, the most characteristic plant of the shingle. To the north of the marsh the shingle edge is partly obscured by dunes, but the *Suaeda* zone is well marked in front of them. The marsh vegetation is that normal to a high marsh. The drainage is intricate, the numerous small creeks sooner or later converging into one large creek which runs to Norton Creek. All the creeks are liable to erosion from the ebb and flow of the waters in them, and the lateral erosion at the ebb is intensified by the drainage from the upper surface of the marshes. When the tide is dropping water falls directly into the creeks, leading to their widening, and sometimes to lateral displacement.

In the smaller creeks, particularly, there is a constant struggle between the action of flowing water and the growth of marsh vegetation. *Obione* especially traps tidal silt, and spreads outwards into the creeks, possibly uniting with a similar mass on the opposite bank. Dams may form in this way, and partly also by undercutting which may lead to the collapse of a part of the bank. Vegetation often consolidates such a dam, thus preventing access of water, except at spring tides, to the part of the creek above the obstruction.[1] A long basin, filled at high tides, is then left. This is one form of salt-pan (5). But many of these pans are not parts of creeks. As vegetation spreads over a marsh it does not do so evenly, but rather from scattered centres. As time goes on it may happen that an uncovered space is left entirely surrounded by plants. For some time such a space will gradually contract owing to the in-spreading of the vegetation, and well-defined pools may be left. Some of these pans have hard floors, others soft; this fact is not yet explained.

The floors of the creeks vary; the deeper and many of the smaller are of sand. In the major creeks this sand is really part of the true substratum of the island. The creek banks may be formed entirely of mud, which is frequently well laminated, but often there is a good deal of sand in the banks. The sand floor of the smaller creeks is not necessarily part of the substratum; the sand may

[1] Sometimes vegetation may spread completely across parts of a creek in such a way as to leave a tunnel below. Deposition can take place on the roof of the tunnel, and an underground stream may be thus formed.

be blown in from the dunes or washed in by high tides, as in the smaller creeks on the upper part of Hut marsh.

While many of the creeks have been built up, and not cut down, as might at first be thought probable, there are some which are cutting backwards into the marshes which they drain. This process is best seen in marshes whose lower parts have a thick carpet of plants, and whose upper parts are bare. The creeks develop in the normal way in the lower part, and the ebb waters draining from the upper, bare part of the marsh concentrate towards the creeks and so lengthen them "backwards" (*e.g.* Missel marsh).

Mud banks, which are common in the larger creeks, are often well colonized by plants, but as the upper level of the banks is usually lower than that of the adjacent marshes, the plants on them are characteristic of a lower level: *e.g.* on the banks *Aster tripolium*, *Suaeda maritima*, and *Salicornia* spp. may grow, whereas on the adjacent marsh such plants as *Obione portulacoides*, *Plantago maritima*, *Triglochin maritimum*, *Limonium vulgare*, etc., are found.

The Sub-structure of the Marshes

A large number, ninety-eight in all, of shallow bores were put down in various parts of the island in 1933. The two most important conclusions reached from this investigation were (1) that sand, sometimes black in colour, seems to be the real "foundation" of the island; and (2) that in some well-defined localities there are pockets of soft mud which seem to represent holes filled up by the deposition of fine mud.

In several bores alternations of sand and mud were found. To obtain an idea how such variations can occur a study of the western end of the island is of help. During the last two or three years erosion has cut through the dunes of the main ridge, and a large fan of shingle has been pushed over the Ternery Mussel marsh. This fan is encroaching on a pocket of soft mud and may in time bury it. Supposing however the breached ridge to remain fairly stable, the fan of shingle and sand may settle a little and mud brought in by the tide will be laid down upon it, just as at present a thin discontinuous layer of mud is gathering over the sandy floor of the newer marshes. Lenticles, or thin sheets of sand, are often formed on the marshes by aeolian action. In high winds much sand is transported in this way. Sand is often redistributed by the smaller creeks, especially where they run near dunes. In all of these ways irregularities of distribution of sediment may take place.

The pockets of soft black mud which occur in, *e.g.*, Plover marsh, under the bare patch in the north-east part of Hut marsh, under much of Plantago marsh, and in the North Cockle Bight (where the mud is on the surface and forms the softest part of the island) are not yet explained. They appear to fill hollows formed by scour, but why such hollows should be found in these places is unknown.

The Evolution of the Island: Formation of Shingle Ridges

The island has grown to the westward. There are two factors which need careful consideration in their effects on this growth, namely tidal currents and wind waves.

(*a*) Tidal currents. Two groups of observations were carried out at different

times to establish the nature of the currents on the foreshore. As will be explained later on, it is important to measure the drift close inshore; currents farther seawards may be quite different. The first group of observations were made with floats, allowance being made for wind action. The floats were thrown at regular intervals clear of the breakers and timed over a given distance. The observations were continued for twelve consecutive hours. The curves so obtained were rather irregular, but generally consistent. They showed clearly that the current runs to the westward up to about two-and-a-half hours before high water, and then after about half an hour it reverses and flows to the east until about three hours before low water.

There are obvious limitations to such an experiment, so it was checked by observing the drift from an anchored boat well away from the shore. These observations were made with an improvised tide-pole which floated out at the end of a line measured in 10-foot intervals. The curves obtained in this way (see Fig. 1) were much more regular than those constructed from the

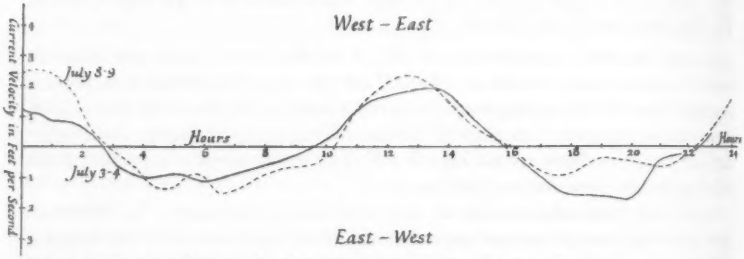


Fig. 1. Current Curves obtained from an anchored boat. The curves are plotted in such a way that high water on 3 and 8 July correspond on the vertical line. Time is measured in hours along the horizontal line. When the curves are above the line the current is flowing to the east, and when they are below the line the direction of flow is to the west

floats, but were in general agreement with them, and established the facts that the direction of flow of the currents and the times of changes in direction were as stated above.

Apart from their own intrinsic interest these curves make it quite clear that the beach owes nothing directly to the influence of tidal currents. First, the shingle, which lies high on the beach, is only touched near high water, and then the current is flowing to the east. Secondly, the speed at which the currents run is insufficient to move shingle. Thirdly, even at high water, the shingle is practically affected only by the breaking waves which nullify the effect of the tidal currents. The currents may have some effect on the sand below the shingle, but any direct measurements on this matter are difficult to obtain. The fact that both the Brancaster and Burnham channels swing east in the sand-flats may be due to the eastward-running current. Direct proof of this is wanting.

(*b*) Wave action. This factor must be considered in close connection with wind direction. As in other parts of the country winds from between west and south are the most frequent. But these are offshore winds on the Norfolk

coast. The dominant winds come from the quarter between north and east, and these set up waves which approach Scolt Head Island obliquely. With a light offshore wind, waves from a north-easterly direction may be breaking on the shore; they are then presumably the result of some disturbance out to sea. Further, relative to the island the greatest amount of open water lies between north and east. When a wave approaches a beach from an oblique angle it swings round so that it does not break synchronously along its whole length. At any one point the swash of the breaking waves is directed obliquely up the beach, and carries pebbles in the same direction. When the swash dies out the backwash of the wave returns directly down the steepest slope to the sea, and also drags some of the pebbles with it. Succeeding waves have a similar effect, and so the pebbles are moved laterally along the beach in a series of curves which approximate to parabolas. This process is known as beach-drifting, and is, undoubtedly, the main factor at work on Scolt Head Island. Many experiments with marked pebbles have been made on the foreshore, and it is clear that waves coming in from any direction from between north and a point south of east cause a westward drift of material. Even quite small waves from the north show the same effect in a small way, but the trend of the beach is of some importance in this respect. West of Scolt Head the beach trends a little south of west, and so the effect of such waves in causing a westward drift of beach material on this stretch is normally greater than elsewhere on the foreshore.

Winds and waves from a north-westerly direction have the reverse effect, and if they persist for a few days may drive material eastwards. There is however no doubt that the dominant direction of travel is to the west, and this can go on no matter what the direction or strength of the tidal current. Experiments made with marked pebbles at several stations along the beach have demonstrated this point conclusively.[1]

Along the Golf Course ridges north-easterly winds and waves have little or no effect, as these ridges are completely sheltered by the island. But north-westerly and westerly winds and waves are certainly of greater importance here, and are probably responsible for the eastward growth of these ridges, just as much as in the past they led to the formation of the ridges south of Norton Creek (see below, p. 489).

Wave action also piles up the shingle, a process which is quite impossible for a tidal current, if for no other reason than that the current does not cover the ridge. After a period of strong onshore winds the beach is combed down and flattened, possibly, in parts, even swept away (see p. 487). Offshore winds have the opposite effect and build up the beach. The combing-down is due mainly to the strong undertow developed by onshore waves, especially if they occur concurrently with high tides and storms.

A further feature of the foreshore is worthy of notice. There can often be seen long, low sand-gullies, usually opening westwards. One is indicated on the 6-inch map off Spiral marsh. They are the product of wave action in piling up the sand in the zone which is exposed at low water. They are temporary

[1] At the extreme eastern end of the island, where the beach turns into Burnham Harbour, the drift of beach material is to south and east. This is so very local that it does not contradict the statement in the text.

features, and in course of time are either driven on to, and become part of, the main beach, or are washed away by a different set of factors acting upon them.

While the westerly growth of the island may be thus satisfactorily explained, it is not easy to say how the recurved or lateral ridges were formed. In fact there seems to be no completely satisfactory explanation of this point. A shingle ridge accumulating near the western end of the island will somewhat naturally turn inwards near its distal end as a result of wave action. Once such a deflection is achieved, waves, because of their tendency to break more or less parallel with the shore, will swing round on to the recurved end and force it farther back. Waves approaching directly from a westerly direction will intensify this effect. The precise angle at which a lateral ridge leaves the main beach, and why so many of the Scolt laterals (*e.g.* Privet Hill and the ridges east of House Hills) change their course about halfway along their lengths, are as yet unsolved problems.[1] They are probably to be related to the amount of open water to the west and south of them at the time of their formation, but this does not of itself throw much light on the problem. At their extreme ends several of the ridges (*e.g.* the Far Point and Beach Point) are curved back almost at right-angles to their trend up to this final curve. This is the direct result of wave action in Brancaster Channel; Beach Point has become more curved of recent years for this reason.

Sometimes a lateral ridge has, near its extremity, been forced back close to or actually on to its predecessor in such a way as to enclose a hollow between them. This is well seen in the two small ridges at the western end of Norton Hills, and again just west of Anchor marsh.

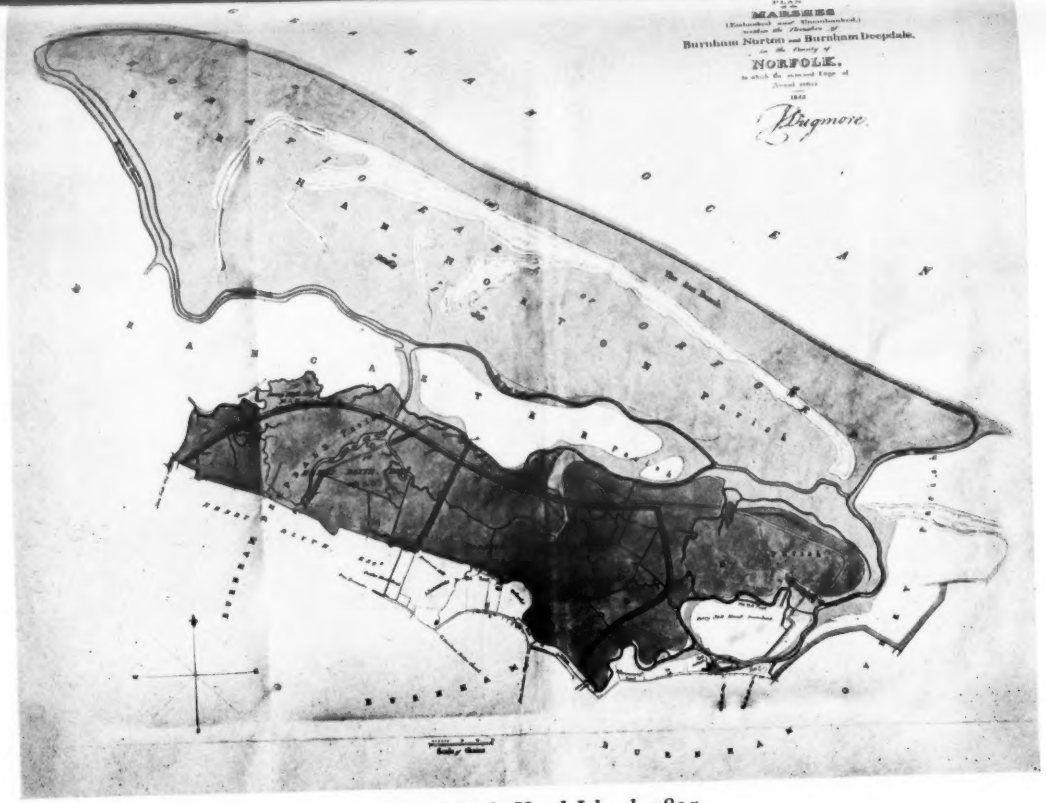
Maps of Scolt Island

Old maps on a large scale of this area are very scarce, and with one or two exceptions give very little help in forming any estimate of the rate of growth of the island.

The earliest map of any interest, though of little use, is contained in the atlas of Lucas Janssen Waghenaer of Enklingven. The date is 1585. "Scolt Head Island" is shown as a spit deflecting the river Burn. This appears to be the only map of early date representing this part of the coast on a large scale.

The next maps of interest are those of Faden (1797); the first edition of the 1-inch Ordnance Survey (1824); Bryant (1826); and a special survey made under the direction of J. Dugmore in connection with the Burnham Enclosure Award in 1825. This map is preserved with the associated deeds in the Shire Hall, Norwich. It is a local survey and may be relied upon more than any other map of the period. It shows the main ridge as continuous; House Hills join the main ridge as they do now; Butcher's Beach and an early stage of the Long Hills are clearly shown. Brancaster and Burnham channels, allowing for the swinging to which they are subject, agree generally with their present positions. Norton Creek is misnamed Thro'land Creek, and by Thro'land Creek is presumably meant Trowland Creek, which is marked but not named. It will be

[1] It should be noted that at Scolt the proportion of shingle to sand is small: much less than at Blakeney Point farther east, and entirely unlike Orford Ness, in Suffolk, where there is practically no sand above mean sea-level. The disproportion of shingle to sand at Scolt may be one of the factors influencing the nature and distribution of the laterals, but exactly how it affects this problem is unknown (6).



Map of Scolt Head Island, 1825

Looking west along the Ternery beach towards the Far Point

Looking east along the island

noticed that the conventional "compass" diagram is in wrong orientation. The draughtsman appears to have assumed that the vertical sides of the map were meridians! (See plate facing p. 486.)

It is interesting to compare this map with the first edition of the 6-inch map (1886). In both these maps it will be noticed that the cartographer has indicated only dune ridges; the laterals, unless covered with dunes, are not shown. The comparison shows that the island had not grown much to the west between 1825 and 1886. Since the latter date the long narrow extension running west from Hut Hills has been constructed. Quite recently (1931–33) about 250 yards of the dunes at their western end have been washed away, and the shingle ridge partly broken through, so that at high tides and storms the waves pass over the beach, and have built up the fan of shingle referred to on p. 483. The shingle ridge however continues on after the gap and terminates in the Far Point. The distance along the curve of the main beach from the Far Point to Hut Hills is about 3/8 miles. This, with its associated laterals and marshes, is the part formed since 1886.[1]

Evolution of the Island and Adjacent Areas

It has been shown that the island has been built westwards, and that each

Fig. 2. Diagram to illustrate the evolution of the island. The heavy line represents the present outline. The more important laterals are shown, but dunes are not indicated. Dotted lines are hypothetical and the letters a to e show the probable order of formation of the ridges. The ridge marked 1 . . . . 17 was the first formed lateral

recurved or lateral ridge represents a former termination of the island. There has also been another movement, a general but not extensive landward retreat of the foreshore. When the waves and scour have removed a good deal of the beach material there are sometimes to be seen on the foreshore opposite Norton Hills outcrops of mud which are quite possibly the marsh mud continued under the present dunes and beach. This inward movement, at any rate along the dune-covered part of the main beach, has now virtually ceased.

The evolution of the island can be shown as in Fig. 2. The "Far Point" of any time has always had a tendency to recurve; sometimes conditions have favoured the construction of a long lateral ridge, at other times only a short one. The figure also shows that the present length of a lateral is not an exact criterion of its original length, for, on account of the inward rolling of the main beach, the present laterals are not necessarily as long as they were at first. The diagram also helps to explain the rather irregular spacing of the laterals.

[1] Another breach was made through the Ternery in February 1934.

If conditions over a considerable period of time favoured a relatively rapid western growth, then only short laterals were probably formed. Conversely, the development of long lateral ridges implies a slow westward growth; compare, *e.g.*, the rapid growth and comparatively short laterals since 1886 and the Long Hills lateral (see folding maps).

We must now turn to the problem of the Great Aster marsh, the largest marsh at the eastern end of the island. It was first suggested by Oliver (1), and later maintained by the present writer and others (6), that Burnham Harbour represents a comparatively recent break-through, and therefore that the island was once continuous with Gun Hill and Holkham Meals or Meols (Dunes). The breach was ascribed to erosion by a storm coinciding with a high tide within the supposed Scolt "spit," so that the impounded waters, once the sea had made the breach low enough, ran out and scoured out a hollow which later developed into Burnham Harbour. The area now covered by the Great Aster marsh was assumed to be rejuvenated by the greater influx of tidal waters through the harbour thus formed. Unless such a rejuvenation is granted on this hypothesis, the occurrence of *Aster* on this marsh presents a great difficulty, because the marsh should have been in an old stage of development and characterized by plants such as occur on the higher marshes to the west of it.

A reconsideration of the problem has led to the conclusion that Burnham Harbour is not of *recent* origin. The reasons for this may now be summarized.

1. The bores put down in Great Aster marsh showed no direct evidence of rejuvenation. No plant-remains such as might be expected to characterize a rejuvenated marsh were found. Instead, the bores showed that mud was accumulating on sand. Incipient channels were developing in a manner strikingly analogous to those on Missel marsh.

2. The marshes on the south side of Norton Creek, and the marsh south and east of Gun Hill, appear to have passed through a perfectly normal evolution. Yet, if a breach had occurred, the position of these marshes is such that they might be expected to show a "rejuvenation" similar to that formerly postulated for the Great Aster marsh.

3. Plantago marsh, north and east of the Great Aster marsh, may be aberrant from an ecological point of view, but it lends, as the bores in it demonstrated, no support to the idea of rejuvenation.

These arguments are supported by certain indirect evidence. If rejuvenation had occurred it is reasonable to suppose that the *original* main channel of Great Aster marsh would have drained to Norton Creek in a direction more or less parallel with that of similar channels farther west. The actual lines of drainage (see map) in the marsh all suggest a normal system of channels, which are still developing, draining to Burnham Harbour.

Gun Hill dunes are prograding to some extent, and there has been some recent dune growth on the island side of the harbour. In fact the harbour seems still to be suffering a certain amount of constriction, which is favourable to the development of a scour strong enough to maintain it in its present position.

Again, it is not easy to see why a breach should take place just here. Sea attack, as at the Golf Club House to-day, may be limited to a small stretch of

shore-line, but there is every reason to suppose, if the break-through hypothesis is assumed, that the dunes here were well developed and able to withstand a severe attack. Further, the marshes within should have been high marshes on which no great amount of water would collect no matter how favourable conditions were. Hence, if the sea did make a breach, it does not seem very probable that there would have been sufficient water within to scour out a deep channel. Again, such channels are seldom made in one storm, and with the general westward travel of beach material the breach would have tended to heal itself sooner or later. As indicated above, it seems more probable that we have to deal with a permanent[1] channel which has become constricted by the growth of shingle and dune ridges towards it.

If it is granted that the harbour is a permanent opening we may have a rather easier explanation for the formation of the shingle ridges, known as Great and Little Ramsey, south of Norton Creek. These ridges are really one main ridge with several laterals running south and east from it. Their position as well as their condition shows that they are old ridges, and they have clearly grown eastwards, *i.e.* in opposition to the island, but similarly to the ridges forming Brancaster Golf Links. At the time of their formation there must certainly have been open water to the north, and possibly north-east of them, and they are probably earlier than any part of the island except, perhaps, part or all of the Norton Hills area. If we suppose a time when Burnham Harbour was a wider entrance than now, it is not going too far to suggest that these ridges were formed under conditions very similar to those under which the Golf Course ridges are being built. The tide had at that time easier access to Overy Staithe, and the saltings known as Overy Marsh had certainly not developed to their present state, and were very likely bare sand- or mud-flats. A comparison of the second edition of the 6-inch map and Dugmore's map (facing p. 486), which in essentials is very similar to the first edition of the 6-inch map, shows that the bulk of the Golf Course ridges had been built prior to the formation of the western tongue of the island. The Ramsey ridges probably formed in a very similar situation; a little of the eastern end of the island may have formed, and the tidal channel to Overy was more extensive. Unless an explanation such as this is given, it must be assumed that the Ramsey ridges accumulated on an open foreshore, and if that were the case a complete reversal of drift must have occurred—an unlikely supposition.

What then is the origin of the island? The theory to be outlined will perhaps be clearer if a short account is given of what appear to be two closely analogous areas in much earlier stages of development.

On the extensive sand-flats off Stiffkey are some shingle and shell ridges which are still very mobile. Some of them are about half a mile long and bend round at their extremities. The waves have had time to separate shingle from sand and construct these ridges. But they have no vegetation on them, and are still liable to be washed over in big tides and storms and to shift their

[1] The hypothesis outlined above does not preclude the possibility that in early times the entrance of Burnham Harbour was rather farther to the east of its present position. When the bar, later to develop into Scolt Head Island, was immature and presumably liable to considerable fluctuations the entrance to Burnham Harbour would naturally oscillate. But the evidence seems entirely to negative a recent break-through.

positions. Given time however and suitable conditions some of these ridges will sooner or later be stabilized and vegetation will grow on them; dunes will form and we shall have structures very similar in every way to those at Thornham, where there are three small "high tide islands." The foreshore here is sandy and very similar to that at Scolt Head Island. Thornham channel flows to the sea between two sand and shingle ridges on which some dunes have been formed. On the most westerly of the "islands" the dunes are mainly concentrated near its extremities; the mid part is little else than a sand-and-shingle ridge with occasional embryo dunes. At its extremities the island curves inwards, the western termination being fundamentally the same kind of structure as the Far Point at Scolt. There is one well-developed lateral ridge.

These small "islands" appear to be growing westwards. The conditions of growth have not been fully analysed, but there is every reason to believe that it is due mainly to wave action in the way described on p. 485.

The point to stress is that here we have embryonic "Scolt Head Islands" arising directly as ridges on a sandy foreshore. The shingle is sorted out from the sand, forms a ridge near high water mark, sooner or later obtains a covering of dunes, and becomes a high water island. This is really a form of offshore bar rather than a true spit.

No matter what view is held about Burnham Harbour, Scolt Head Island presents fundamentally the same problem. Burnham Harbour is closely analogous to Thornham Harbour. To the east are Holkham dunes, the counterpart of the eastern "island" at Thornham; to the west is Scolt Head Island corresponding to the western "island." But at Scolt conditions were more favourable to a comparatively rapid western growth, and concurrent with this growth the successive laterals were formed. Dunes may not have grown along the whole length of the main beach ridge of the island. To-day Smugglers' Gap is filling up with new dunes. But the ridge of shingle seems to have been continuous; there is nothing in the nature of the marshes or laterals to suggest a growth from two or more nuclei.

As the island grew in size it became relatively stable. In its early stages the main ridge was swept by storms and rolled landwards. Now that the ridge is dune covered this motion has virtually ceased, although the sea has sometimes broken through the low dunes in Smugglers' Gap and still breaks through (see p. 483) those in the Ternery beach (see note, p. 487).

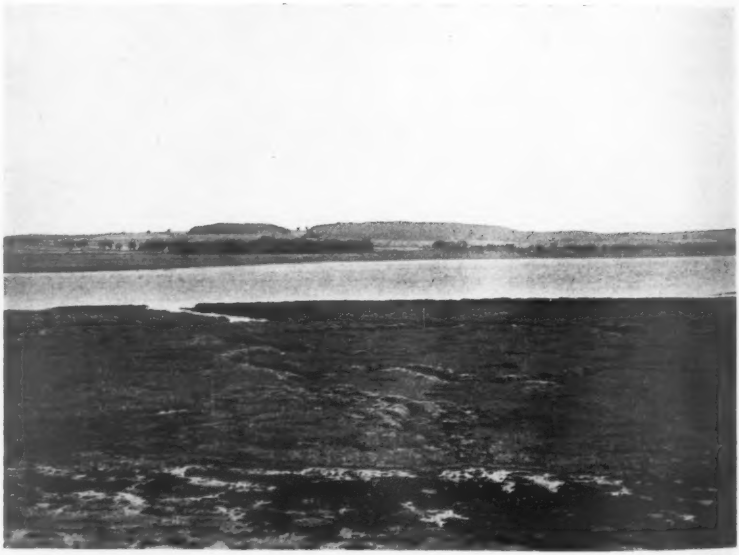
As the main ridge extended it became easier for shingle to travel along it and to be swept round its western extremity to form lateral ridges. It is a fact that the best developments of shingle on the island are on the terminal and lateral ridges rather than on the foreshore.

In short, the origin of the island was probably as follows. First there was an extensive sandy foreshore with some shingle. The waves separated out shingle from sand, and sooner or later piled up the shingle into ridges near high water mark and so formed an offshore bar. The early ridges were unstable and mobile. Eventually one became more stable, and dunes began to grow on it, and it gradually extended westwards, sending out a succession of recurved ends which now exist as laterals. At this stage the main ridge was probably added to by newer ridges formed by the waves and pushed back on to the main ridge, a process which can still be seen in action. A walk along the

A shingle lateral running landwards from the Ternery beach; the plants are mainly "Suaeda fruticosa"

A salt pan

The Hut Hills, and the Hut



Phot. L. Slater

Looking south from Butcher's Beach across Norton Creek; creeks lined with "Obione portulacoides" in foreground, and higher ground of mainland in the distance

foreshore to-day usually shows one or more long, low, and relatively broad sand ridges which have a channel, draining westwards, between them and the main ridge; these are sometimes pushed back by the waves and so come to form an integral part of the main ridge. Near the Ternery, ridges, often largely composed of shingle, are formed from time to time and are pushed on to the Ternery ridge, and the material thus added is sooner or later swept round to the Far Point ridge and strengthens it. At other times, under certain conditions of wind and tide, these new ridges are of sufficient size to form a new and permanent addition to the island, and the old Far Point ridge is not added to but remains as the last recurved end, the newer ridge taking its place as the terminal of the island.

One further feature calls for attention. Spits and offshore bars such as Blakeney Point and Scolt do not run strictly parallel to the adjacent coastline, but at a slight angle to it. Scolt Head Island, from Burnham Harbour to the Headland, runs rather to the north of west, and this direction is more noticeable if the trend of Burnham Hills is considered. It has been argued by W. V. Lewis (7) that this tendency of a spit or bar to form at an angle to the land is due to the waves to which it owes its origin trying to build it at right-angles to their dominant line of approach. At Scolt this is from a point between north and east, and if Lewis's reasoning be valid we have here an explanation for the inclination of the island to the mainland. This view is not contradictory to what has been said about the present westward travel of beach material; the waves will still approach somewhat obliquely, because the spit can never, in such an environment as that of Scolt Head Island, turn at a complete right-angle to wave approach. The more it tries to do so, the more is its distal end forced into deeper water, and so subjected to greater wave action, which necessarily drives it back. The actual direction therefore is a resultant of two forces, and the change in trend which takes place at the western end of Hut Hills (*i.e.* Scolt Head) gives interesting testimony on this matter.

Scolt Head Island and the North Norfolk Coast

Finally, something must be said of the relation of the island to the north Norfolk coast as a whole. The coastline between Old Hunstanton to the east of Blakeney Point really forms a unit. It is an excellent example of a marshland coast. Starting at Old Hunstanton and running eastwards as far as Holme is an extensive development of dunes, now partly used as golf links. The dunes rest on shingle ridges and, alongside part of the links, give evidence of a prograding shore. At the eastern end of the links a shingle spit continues their general trend and encloses Holme marsh. The spit has recently been breached and a large fan of shingle thrown over part of the marsh. The shingle has extended eastward, in a direction opposite to that of Scolt Head Island and Blakeney Point. The marsh within shows a development normal to the Norfolk coast marshes (8). The eastward growth of the shingle ridge, the erosion it has suffered, and the prograding of the dunes are all points which would repay further study. Along this coast from Old Hunstanton to Scolt Head Island are submerged forests, found also in Brancaster Harbour, which show by their position that Scolt Head Island is of later date than the lowest forest bed (9).

The drainage of Holme marsh concentrates in one channel reaching the sea near Gore Point, which is suffering erosion. From here as far as Thornham the marshes have been reclaimed and afford excellent pasture. Near Thornham a belt of conifers has been planted to hold the dunes.

Thornham has already been mentioned. The "islands" are growing up on the flats, and marshes have developed behind them and increase in age as they are traced from west to east. East of Thornham is another reclaimed area extending as far as the Club House on Brancaster Links. Then follow the Golf Course ridges which have already been described.

East of Scolt Head Island similar features are found. From Burnham Harbour to Wells are the dune ranges (see p. 488) in part held by conifers, and enclosing reclaimed marshes on Lord Leicester's property. East of Wells is a complex stretch of coast. The sand-flats are here very wide, and immediately east of the harbour are backed by an extensive system of dunes and marshes separated by shingle ridges, etc. The "lows" between the ridges are well developed, and the physiography and ecology of the area require attention. The dunes and marshes then give way to a wide sandy foreshore, on which the horizontal distance between high and low water marks at spring tides is about 2 miles. Here, on the seaward side of the flats, are the ridges described on p. 489. Near high water mark the flats often give way to mud and the early stages of marsh growth. A long shingle ridge, running roughly parallel to the shore, separates a lavender marsh from the marshes of the open shore off Stiffkey. This ridge does not reach Morston, between which place and Blakeney "Pit" are extensive mud deposits.

The eastern side of Blakeney Harbour is the distal end of Blakeney Point which has been fully described by Oliver (10) and others. It will now be convenient to reverse our direction and trace the main features of Blakeney Point from the east.

In many respects Blakeney Point and Scolt Head Island resemble one another; in others they are very different. The fundamental difference between the two is the great bank of mobile shingle which runs from Weybourne to Blakeney Far Point. Dunes only occur near the western end of this ridge. From Weybourne cliffs as far as Cley wall the bar encloses reclaimed marshes which have not been very successfully protected by their defences. Just west of Cley wall the River Glaven flows to the inner margin of the shingle ridge and continues to do so for some little distance until it turns back into the marshes. Blakeney Point is a spit, another respect in which it differs from Scolt Head Island. Near Cley the sand-flats, which extend all the way from the Wash, disappear, and east of this place the shingle ridge falls off steeply into deep water. This is most marked at Weybourne Hope, which is the real "end" of the marshland coast, the more so as at this village the cliffs which run on past Sheringham and Cromer begin.

Blakeney Point shows a good development of lateral ridges which are arranged in groups to a rather more marked extent than are those at Scolt. The easternmost group is named the Marams, and consists of eight ridges enclosing narrow-mouthed marshes between them. A break follows, and the next group, capped by dunes, is known as the Hood. After another break the finest development of dune ridges on the Point is found, that of the Long

Hills and the Headland. These dunes enclose very good examples of lows between them.

Westwards of the Headland is a long and comparatively new continuation of the shingle spit which terminates in what is its more attractive feature, the Far Point. This is both like and unlike the Ternery at Scolt. The ridge connecting the Ternery to Scolt Head has several recurved ridges running back from it, the last ridge forming the Far Point of the island. At Blakeney Point the recurved ridges are all near the extremity of the shingle ridge connecting them with the Headland, so that the Far Point at Blakeney is a much more self-contained and distinctive region than is that at Scolt.

Emphasis must also be laid upon the greater development of marshes at Scolt Head Island. The Scolt laterals are usually longer than are those at Blakeney Point, and the marshes enclosed by them are generally in a later stage of development. As Blakeney spit is continuous throughout, there is nothing there corresponding with the Great Aster marsh at Scolt.

Blakeney Point, like Scolt Head Island, has grown from east to west. The factors governing their growth are the same in both places. Beach-drifting as a result of wave action is certainly the dominant factor. At Blakeney Point, also, the greatest stretch of open water is to the north and east, and it is waves coming from off this stretch which, in the way described on p. 485, cause beach material to move westwards. It may here be remarked that the flood current runs against the growth of Blakeney Point, and for this and other reasons cannot have any constructive effect in lengthening it (6), (11).

Throughout all this stretch of coast from Weybourne to the cliffs at Hunstanton, the "old" shore-line can be traced as a belt of rising ground within the marshes, natural and reclaimed.

From this brief survey it can be seen that Scolt Head Island forms but a fragment of the whole. It is part of a more extensive area, but as it is an island and, all things considered, so clearly marked off by nature from its surroundings, it may be regarded as an entity. Yet the full study of the problems of the island involves a study of the many other features of this shore-line. These have not yet been worked out, but they should afford excellent scope for field workers in many branches of science.

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DISCUSSION

Before the paper the PRESIDENT (Major-General Sir PERCY COX) said: The paper we are to hear this afternoon, as you know, is on the subject of Scolt Head Island. You will probably all have looked at your map of Norfolk. In case you have not, Scolt Head Island is about 8 or 9 miles east of Hunstanton. The standpoint from which we are going to hear Scolt Head Island discussed this afternoon is the geomorphological; that is, the evolution of the island and its changes of form in the course of centuries; how the island has been built up from the marshes. When you think of it you realize that an unusual amount of attention has been directed to this small piece of the Norfolk coast during the last few years, and I believe the primary reason for Scolt Head Island coming thus into the limelight was the existence of the colonies of terns which have bred there from time immemorial; and likewise at Blakeney, to the eastward. Those colonies directed attention to Scolt Head Island; and the locality being so get-at-able from Cambridge, where there are always professors and young students of different branches of natural history anxious to get practical material to work upon, Scolt Head Island has become a very useful field for them and has given rise to a great deal of interesting and valuable study of conditions exemplified on that particular piece of coast.

Our lecturer this afternoon is Mr. J. A. Steers, who at present occupies the post of Lecturer in Geography in the University of Cambridge, and is well known to this Society. He was one of those who, with Mr. Michael Spender, represented our interests on the Great Barrier Reef Queensland Expedition of 1928–29, and on his return he read a very interesting paper to us on that subject. Ever since Mr. Steers took up the close study of coast geography he has been giving particular attention to Scolt Head Island. I will ask him now to deliver his paper.

Mr. Steers then read the paper printed above, and a discussion followed.

The PRESIDENT: Mr. Godwin is a Fellow of Clare College, Cambridge, and University Lecturer in Botany, who has especially interested himself in submerged forests.

Dr. H. GODWIN: One of the chief difficulties in dealing with the geology of such extremely recent deposits as those that make up Scolt Head Island and the coast is the absence of suitable chronological indices. The time has been too short for the evolution of new species of plants and animals which might serve as zone fossils, and few or no human remains are found *in situ*. A method which promises help in such a case is that of pollen analysis which was developed by Von Post and Lagerheim in Sweden only twenty years ago. This method is based on the fact that the pollen of wind-pollinated plants, such as grasses, sedges, and various trees, is abundantly produced, widely disseminated and incorporated in all kinds of growing deposits. Thus, if in these deposits conditions are present which inhibit decay, the membranes of the pollen grains remain almost indefinitely preserved. Peat beds are especially favourable to this type of preservation, and by treatment of a sample of peat with caustic potash, samples can be made up for microscopical observation, and in them the chief genera and, in some cases, the chief species of pollen-bearing plants can be identified. In this way the examination of a vertical series of samples through a

peat bed gives the history of the surrounding vegetation during the whole time the peat bed has been forming.

In the pollen content which can be examined in this way, tree pollen is much the most important because, in the first place, the trees are the natural vegetation dominants in this part of Europe, and, in the second place, on that account, they are the natural climatic indices; and, in the third place, as the dominant vegetation they must have strongly influenced the lives and cultures of prehistoric people.

Records of post-glacial forest cover have been made by pollen-analysis from many places over Europe, and invariably three phases are recognizable. First, a phase of climatic amelioration in which successive waves of forest trees spread northwards across Europe following at a distance the retreating ice front: in this

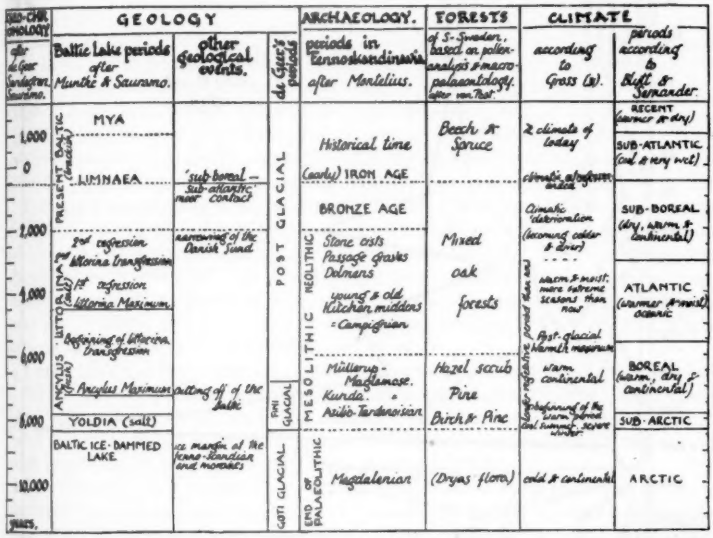


Fig. 3. Tentative correlation scheme showing correlation of geochronology, geology, archaeology, and the forest and climatic periods, in the South Baltic region: slightly modified from Gross

phase there were forests of birch and pine, afterwards hazel, and then immigration of the warm-climate trees, oak, elm, lime, and alder. These, in the second period, the climatic maximum, rose to complete dominance. At the end of that period the hornbeam and beech began to spread. Finally there has been a period less well marked than the others, of climatic retrogression especially marked by southerly readvance of the northern coniferous forests. These successive phases can be recognized over the whole of Europe, and these and the details of the succession can be correlated with other kinds of chronological indices.

In southern Germany, for instance, Karl Bertsch has correlated the successive forest periods with archaeological horizons stratified into the deposits of the Tedersee basin. Not only have the forest periods been correlated with the archaeological but also with geological periods, such, for instance, as the Baltic lake periods, with geological events, such as the submergence of the North Sea,

and with the climatic periods set out by Blytt and Sernander. All these have in turn been correlated with the geochronology of de Geer, which is based on the lake sediments of the area. A tentative correlation scheme for south Sweden is set out in Fig. 3. By such correlation it would appear, for instance, that the transition between the Boreal and Atlantic climatic periods corresponds to the transition period between pine-birch woods and oak forests.

In a general way this scheme applies to the whole of north-west Europe, and the point now raised is its application to the history of the formation of Scolt Head Island. At Scolt Head there are peat deposits in three different places.

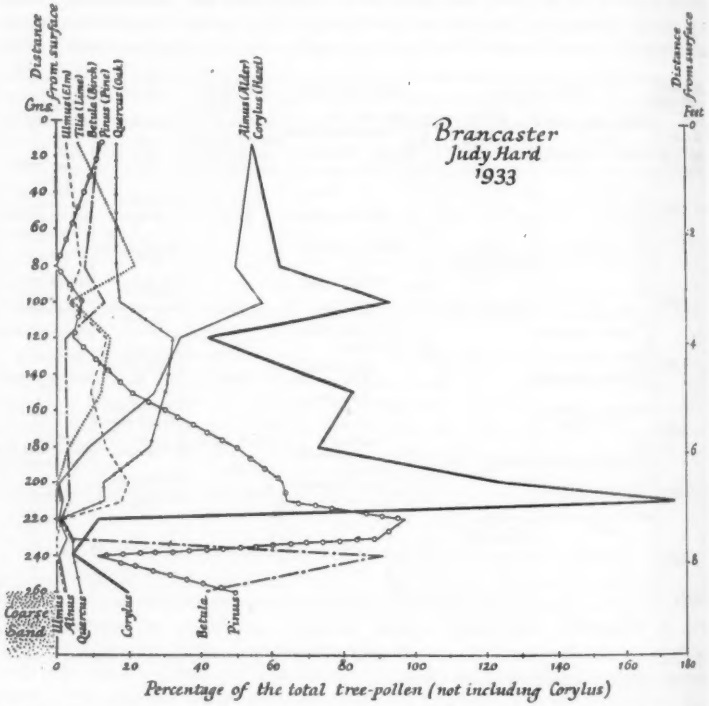


Fig. 4. Pollen-analysis of the peat sequence in Judy Hard. The upper surface of the bed is approximately −1·5 feet O. D. Each sample is based on a count of 150 tree pollen grains

One, at Judy Hard, is in the main channel quite near to Brancaster Staithe; another is farther out but still on the harbour channel, and the third is on the Hunstanton side of Scolt Head where two separate beds of peat are exposed on the foreshore by the Golf Club House. Of these three sites the most important is that at Judy Hard, where the upper surface of the peat bed is at about minus 1·5 feet O.D., and the base of it minus 10 feet O.D. By a suitable borer samples have been taken in vertical series right through the deposit, and my wife and I have undertaken the pollen analysis of them. The results are shown in Fig. 4. It will be seen that the base of the peat bed is characterized by a high percentage

of birch and a considerable amount of pine, and then there is a phase in which the hazel pollen reaches the enormous percentage of over 170 per cent. of the total tree-pollen (hazel is not itself counted as tree pollen). The alder, the elm, and the oak are already present, but they do not begin to rise in importance until later, and then they become of dominant importance as the pine disappears.

The importance of these features is that they are without question indicative of that period to which I have previously referred, that is, the transition from the Boreal period to the Atlantic period. From the correlation table of Fig. 3 it appears that this transition took place about 6000 B.C. This is of importance because the peat bed underlies the marsh flats or saltings which lie inshore from Scolt Head, and which evidently predate the formation of the island. We cannot say with any exactitude when the top of that peat bed would be formed, but assuming a normal rate of peat formation it would presumably be round about 4000 to 5000 B.C., and Scolt Head Island must certainly be later than that.

The other point is that since the base is now at minus 10 feet O.D., there must have been a change in the relative position of land and sea since the end of the Boreal period amounting to at least 20 feet, because peat cannot grow within reach of high tide. We do not know how much above reach of the highest tides this bed formed, so that 20 feet is the minimum value for the movement. Such relative movement of land and sea is undoubtedly a factor of importance in any consideration of the mechanism by which the island has been built up.

I do not propose now to say what were the results of the analysis of the other peat beds, except to indicate that there were two other exposures on the shore which were of very different ages from one another, and from anything that could be seen in the first. They both post-dated it. Thus it is clearly erroneous, in talking about this coast-line, to speak of "the submerged forest" or "the coastal peat bed." There appear to be in the neighbourhood of Scolt Head and Brancaster at least three peat beds of different dates.

I am afraid this is a somewhat specialized attack on a very local problem, but I think it does contribute a little towards an exact knowledge of the time when the island took its origin, and calls attention to a technique which promises to be of value in dating those oscillations of land and sea level which must have been largely concerned in the evolution of our coast-line.

The PRESIDENT: Captain Diver read a paper to the Society a year ago on a similar formation in Poole Harbour. We should like to hear him on this subject.

Captain C. DIVER: I really came here to learn; indeed, I am not particularly qualified to comment on Mr. Steers's paper because I have not been to Scolt Head, and I am only a biologist. But I have been extremely interested in the paper, because Mr. Steers is doing very thoroughly at Scolt Head what we have been trying to do in our own way at Studland. He is able to bring to his work a knowledge and experience on the geographical side which we unfortunately lack.

Speaking after Mr. Steers's paper before this Society in 1927 Professor Oliver referred to Blakeney Point and Scolt Head as the kindergarten of shore studies where land-building is concerned. All I can say is that if the problems that we have had put before us so well this afternoon by Mr. Steers are the problems that face the physical kindergarten, my sympathy goes out to those who are engaged in post-graduate studies in this science. Now that Mr. Steers has passed through this preliminary phase of his education I would ask him if he cannot take a little leisure, and come for a change down to the Dorset coast to put us on the straight and narrow path in our problems there.

I gather from him that along the east coast there is a graded series, from Orford Ness to Scolt Head, graded in regard to the proportion of shingle and sand that forms these spits. Now, at Studland we have the end-term of that

series: we are only concerned with sand. And for the sound reason that in any scientific investigation it is always advisable to eliminate all the variables one can, I would ask Mr. Steers to bring our dunes within the scope of his inquiry.

The question that always comes to my mind in looking at dune formations is what is the primary cause of the rhythmical or ripple effect, the succession of ridges and slacks. These large-scale ripples, like their small-scale counterparts, appear to lie at right angles across the line of motion, in this case across the line of growth, and it seems to me that at Scolt Head this problem is not seen in its simplest form. The cause of the westward growth, if I understand Mr. Steers correctly, is not the shallowing of the offshore waters at the western end but the erosion forces operating along the whole of the north flank shifting the beach material steadily westward and giving that long backbone from which the laterals spring like ribs. At Studland what corresponds to the Scolt Head laterals are our main ridges. We have nothing corresponding to the backbone, though if the very rapid and recent erosion now going on along our north flank continues at its present rate, we shall, presumably, get a short backbone built up from which the main ridges will appear to spring as if they were laterals.

I am not quite clear what answer Mr. Steers gives to this question. If there is a simple answer I should be very grateful to be put out of my ignorance. The answer, if I understand him, that the laterals are the product of the material that is drifting westward being swung round when it gets to the end may be applicable, and it certainly looks as if it were applicable to Scolt Head, but it is clearly not applicable to the Studland dunes, where there is no interference of that sort. In our case it is a steady rhythmical growth, but eastwards instead of westwards.

The formation of the bare pans in the marshes is a very attractive problem, and I think it is one that ought to receive the attention of students of plant populations.

In conclusion, I should like humbly to offer my congratulations to Mr. Steers on his progress in this valuable work.

The PRESIDENT: Mr. Chapman, would you kindly come up for a few moments? Mr. Chapman is a student of botany at Cambridge University, a member of Caius, who has made an intensive study of Scolt Head Island from that point of view. It would be interesting if he would tell us something of his researches.

Mr. V. J. CHAPMAN: Scolt Head Island forms an area that is admirably suited to the study of ecology, because the relative frequency of the physiographic changes that are taking place there is reflected in the changes of the flora. Normally any study of vegetational change is limited by the personal time factor of the investigator concerned, but in a case of this sort such a factor is reduced very considerably.

My purpose is to give you some idea of the methods by which we are attacking the ecological problems that are presented to us on Scolt Head Island. One of the fundamental principles of the investigation is the use of plants as indicators of the conditions under which they grow. As an example, I may cite the case of *Prosopis*, the mesquite bush which, when found growing in the desert plains of America, indicates soil water fairly near the surface. Such an indication in an arid area is of considerable importance. But apart from individual species, plant communities may also act as indicators of the conditions. You are all familiar with the changes of vegetation that occur as you climb up a mountain, and the varying zones of vegetation that you pass through reflect and indicate the changes that are taking place simultaneously in the local climatic conditions. At Scolt Head Island it is probable that the zones of vegetation which are to be found along the stable shingle laterals, mentioned by Mr. Steers, belong to this type of static zonation.

In the slide Mr. Steers showed you will have noticed that along the sides of those stable laterals there was a large mass of *Suaeda fruticosa*. This is the dominant plant of the lowest zone, the next higher zone being dominated by *Statice binervosa* and *Frankenia laeris*, whilst on the crest of these laterals you will find *Psamma arenaria*, *Armeria maritima*, and sometimes *Colycesia maritima*. These zones are fairly constant so long as the shingle laterals are of any size. The conditions which determine this zonation are probably three in number: (1) The degree of submergence and emergence which the plants undergo at the different levels; (2) the stability of the substratum on which they are growing; and also (3) the quality and quantity of the soil. All these factors will show a regular gradation from the summits to the bases of the stable shingle ridges.

The vegetational zonation of an area is not always static. Round a Norfolk broad, for example, one may find a reed swamp around the edge, outside this a zone of carr (reed swamp invaded by bushes of willow and alder), and finally, farthest away from the broad, a woodland zone. If one came back to such an area after an absence of fifty or seventy years, one would probably find that the reed swamp had advanced farther towards the centre of the broad and had been followed by the carr and woodland, all three zones closing in upon the broad. Such a zonation is termed "developmental," and in the process a number of stages may be interpolated, and these stages, taken together, form what is called the plant succession. Successions that commence upon primary bare areas (that is, areas which have never before had any vegetation on them) are known as priseres. Mr. Steers has pointed out that Scolt Head Island is built up from shingle, sand, and mud, and these materials form the base substrata which are colonized sooner or later by plants. Therefore the vegetational successions that we see taking place upon the dunes, marshes, and shingle ridges are all to be classed as priseres, and it is with priseres that we are concerned fundamentally at Scolt Head Island.

Once the initial stages have been passed, that is, the invasion and establishment of the first colonists, the further stages in the succession may be brought about by the operation of external factors alone, and when this is so the succession is termed an allogenic succession. As an example I may cite the colonization of embryo fore dunes by *Psamma arenaria*. *Psamma* can only colonize the fore dunes when they have reached a height such that inundation by the tide will be rare, or completely absent. It will colonize the dunes when that height is reached irrespective of whether any vegetation has gone before. In fact, its presence is determined entirely by the external factor of height, but when plants have once become established, then further changes may be influenced by the presence of the plant species. When the succession is being influenced by the plants that are already there, then you are dealing with a succession which is termed autogenic. As examples we may cite the final stages of the marsh succession and the final stages of the dune succession at Scolt Head Island. *Psamma arenaria*, by the binding power of its roots, compacts the sand and makes it a habitat which other species can invade. In the same way, the species on the marshes collect, or rather trap, the silt carried by the tide; the marsh height is raised and other species are enabled to invade an area that formerly they could not, because the conditions at the lower level were unfavourable for their existence.

The important distinction between the allogenic and autogenic components of the succession lies in the fact that in an autogenic succession the plants are not only acting as indicators of the conditions but also as physiographic agents. Any succession usually has both an allogenic and autogenic component, but of these only one is generally dominant. It commonly happens that the allogenic com-

ponent is prominent in the early stages of the succession and the autogenic component becomes dominant towards the end, but the phase at which the allogenic may be replaced by the autogenic component varies in the different successions.

Finally, in any succession the inter-relations of the plants to themselves and to the environmental factors is of extreme importance; the response of the plants to the environmental conditions and their reaction upon them become exceedingly important. I want to show you a few slides in order to illustrate this point from work that we have done at Scolt Head Island.

The slides illustrate some results of the work that has been done upon the action of the factor "submergence and exposure" in determining the relative heights of the different plant communities. The first slide shows the hours of submergence per month that the different salt marsh communities undergo. It will be noticed how the hours of submergence per month vary with the heights of the different species involved. The *Zosteretum* (lowest marsh community) undergoes 130 to 280 hours' submergence per month at its upper and lower level respectively, whereas the *Juncetum*, which is the highest marsh community on the island, undergoes only 2½ to 10 hours' submergence per month at its upper and lower level respectively. You will realize therefore that the conditions operating on the two different communities vary considerably. A table has been constructed concerning the species composing the different marsh communities, and this shows the number of times per annum that each species is submerged. Taking the lowest phanerogamic species, *Zostera nana*, and the highest, *Juncus maritimus*, we note that *Zostera nana* undergoes 495 to 705 submergences per annum, whereas *Juncus* only undergoes 75 to 165, the figures being given for the upper and lower levels respectively.

Another diagram indicates the occurrence and duration of the periods of continuous exposure that any species undergoes, and when I say continuous exposure I mean periods during which no tide covers the different species. Again, it will be seen that the conditions under which each species lives are exceedingly varied. It is obvious that the response of the plants to these varied conditions, and their reactions upon them will largely determine the upward and downward spread of the different species and communities. Similarly, the continued existence of a species or community on a given marsh until the time when they are replaced by other species or other marsh communities will be dependent upon their response to the changing conditions.

This has been a very scrappy account of the vegetational changes taking place, but it may serve to give some idea of the line of attack we are taking in working out the ecology of Scolt Head Island.

The PRESIDENT: Mr. Peel, will you speak to us a few moments on the question of survey? Mr. Peel was the surveyor who did the mapping. He is also a student at Cambridge.

Mr. R. F. PEEL: The primary need of the physiographer in studying such an area as Scolt Head Island is a detailed and reliable map upon which he may base his deductions. In the case under discussion no map existed which showed the necessary detail. The best map available was the 1907 (revised) Edition of the Ordnance Survey 6-inch map. I have no slide of this map, and so will have to content myself with saying that, while its portrayal of the mainland features and the creek-systems was admirable, it showed very little of the detailed structure of the island. The dune systems were shown, but the shingle-ridges upon which they rest, and which form the essential "skeleton" of the island, as Mr. Steers has pointed out, were either omitted altogether, or shown only by generalized outlines. In addition to these deficiencies were errors introduced by subsequent changes in the outline of the island. We were dealing here with an area in which

evolution is comparatively rapid, and any map produced will necessarily be out of date in a very few years.

Faced with these difficulties, the most satisfactory procedure would have been a complete resurvey of the whole area, laying emphasis on the important structural features. In the limited time available however, and in the absence of the expensive instruments necessary, no such plan could be adopted, and eventually the problem was solved by a compromise. The Ordnance Survey 6-inch sheets were taken as a basis, and the detailed outlines of the shingle ridges and other features were superimposed over the generalized outlines of the existing map. The method used was that of normal plane-table resection, prominent buildings, flagstaffs, etc., on the mainland serving as fixed marks. The whole area could not be resurveyed in the time available, even on this system; but only such areas as were of little significance to the greater problems, and which could not have experienced appreciable alterations since 1907, were left untouched. The whole of the island was remapped, and much detail was added to the adjoining dune areas to the east and west, but the complex creek system was checked over only in such parts as might have experienced changes. The greatest changes were found to have occurred at the western extremity of the island, and here the greatest care was needed in fixing the new outlines. Over the greater part of the remainder of the map the work resolved itself into adding such detail as we considered necessary, and checking over the old outlines to determine whether any changes had occurred.

The actual field-work occupied about a month in 1932, but portions of the map were resurveyed in 1933, and any alterations noted were incorporated in the final map which Mr. Steers showed you in his paper.

The PRESIDENT: Professor Debenham, before I ask the lecturer to answer one or two of the conundrums that have been put, would you add a word or two? You know the ground so well.

Professor DEBENHAM: I could have wished that the President had seen another Captain Diver in the audience; some one who would come up and suggest further problems in other parts and, perhaps, cross-examine Mr. Steers a little. I feel that I am only another contributor to the chorus from Cambridge, but I am glad to be able to add my congratulations to those of other speakers. As our President has said, Scolt Head Island has become a field laboratory for several departments in Cambridge, and as far as activity and occupation of the ground is concerned I suppose my department is in the forefront. A good many of my geography students are there each year for various periods during the year, certainly most of the summer, largely under the tutelage of Mr. Steers.

I think you will have gathered from the paper and from the speakers who followed how very comprehensive a problem the evolution of an island very soon becomes. You go to a small patch of shingle and sand, which is all that Scolt Head Island is, and say: I shall attack this problem. Why is it there? How did it grow? You begin to make a survey. Then you begin to see plants doing things and, before long, you get out of your own depth and have to call in a botanist. You find that tidal currents and waves may have something to do with the problems and you become a hydrographical surveyor. The farther you go the more complete the problem becomes and the greater the need for specialists.

Captain Diver hinted that we were beyond the kindergarten stage at Scolt Head Island. When Dr. Godwin talks about counting and recognizing pollen-grains, I feel we have hardly reached the kindergarten stage, that is, speaking for the geographers. We can map the changes and we can investigate the physical geography of the island, but the evolution of the island as a whole cannot

be proved by physical geography alone. We have to call in more and more specialists.

Mr. J. A. STEERS: I do not think I can answer Captain Diver's queries completely. The "shingle" island has grown westwards, and each lateral ridge represents a former "Far Point" of the island. The shingle travels to the west as a result of beach-drifting, but the precise mechanism by which the laterals are constructed is obscure. The distal end of the island at any time is in unstable equilibrium, and wind-waves easily turn it inwards. The building of a new "Far Point" ridge, in such a way as to have its predecessor as the last lateral, seems to take place when for some reason or other westward beach-drifting is greater than normal. I do not know of any detailed analysis of the actual process. Our yearly mapping of the Ternery may throw light on this in course of time. The final curves of the lateral ridges are probably all due to waves set up by west and south-west winds in the harbour: such winds, and especially those from the north-west, must have a considerable effect in causing the main outer ridge to curve round and to become a lateral. The inward-rolling of those parts of the Ternery and Far Point ridges which are not dune-covered accounts satisfactorily for the abrupt angle at which the laterals now meet the main ridge.

We are publishing a fairly comprehensive book on the Natural History of the Island, and Dr. Godwin and Mr. Chapman have indicated this afternoon some of the ecological and other problems which the area presents. There are also others present—Mr. Oldham, Mr. Marquand, and Miss Dickinson—who have also helped in this work. The island is a self-contained unit, and because it is a National Trust area it is possible to carry out experiments and observations, often over a long period, which would be impossible, or at least very difficult, elsewhere. Professor Debenham has suggested how important is co-ordinated work of this kind.

Finally, I should like to call attention to the detailed map. Mr. Peel, in his remarks, made it appear that his work was of less value than was actually the case. He was helped a good deal by Mr. S. Dicks, but the greater part of the new mapping and the final production of the large map shown on the screen was entirely his own work.

The PRESIDENT: It remains for me to wind up the debate. I am sure all of us have been amazed at the number of interesting problems which the study of Scolt Head Island evolved. It has been satisfactory from my point of view as a non-scientific layman to see how well the various branches of science have been worked out and exemplified in these young students and undergraduates, and what a very valuable asset Scolt Head Island is to them. I cannot go into the discussion of any of the technical problems that have been raised. I will only ask you to join with me in thanking Mr. Steers very much for his informative paper, and the other speakers whose observations have added so much to the interest of the afternoon.

THE SUITABILITY OF THE PORT OF DOVER AS AN OUTLET FOR ITS DEVELOPING HINTERLAND

I. E. MUDDLE, Bedford College, University of London

DOVER is the chief port, excluding London, for south-eastern England, which has hitherto been largely agricultural, while the chief importance of the town has been in its control of the shortest cross-Channel routes. Its future however will be affected by the developing East Kent coalfield which lies in its hinterland. Although some of the coal will be used locally and in London, a port will be needed to deal with the trade of the coalfield and of the anticipated industrial areas. The development of the region will be considerably affected by its possession of a suitable port; several outlets have been suggested, and of these Dover seems the most probable choice, although not wholly satisfactory.

The hinterland of Dover is restricted by its nearness to London and by the ports around the coast. For some commodities it includes East and South-West Kent and East Sussex, but on the margins trade is taken by Newhaven and, to a smaller extent, by Shoreham and Littlehampton on the south coast, and by Rochester and the smaller port of Faversham on the north. Within East Kent itself, Dover loses some trade to other ports, of which Folkestone, the chief, surpassed it in some pre-war years and during the War; while Ramsgate has only a small trade and that of Sandwich is almost negligible. In the immediate hinterland of Dover great economic changes are taking place. It does not extend quite as far north as the lower Stour, since Sandwich has some local trade, and, north of the Stour, communications with Ramsgate are better than those with Dover. On the west, it is bounded by the eastern hills of the Nailbourne valley, which is served by Folkestone, and, on the south, it is limited by proximity to the latter. The unshared hinterland of Dover thus corresponds roughly with the East Kent coalfield, except in the Stour valley, including the Chislet mine. In this position Dover should be more favourably affected by the coalfield than any of the ports at present established; but considerable uncertainty prevails as to whether it is wholly suitable as the required outlet, and it may be found preferable to develop an entirely new one.

The export of the coal from Dover, or from any other port, will be limited by its amount, quality, and price, the latter depending mainly upon local physical conditions, although also influenced by external factors. It is as yet impossible to estimate, with any degree of accuracy, the amount of coal available, but it is known to be sufficiently large to justify the establishment of new towns, new railways, and new port facilities on a considerable scale. Its quality varies from a good steam coal, such as that at Ripple, to a gas and manufacturing coal, as at Waldershare. Although much of it is not of as good a quality as was hoped at first, it is considered suitable for industries, and the steam coal will be invaluable for bunkering at Dover. Mining is very expensive in this region, where the mines are the deepest in the British Isles, owing to the great thickness of later strata and of the unproductive upper part of the coal measures. The cost is increased by the need of pumping water from the overlying strata, although this difficulty lessens towards the north-east, where the water-bearing

sands thin out, but the increasing thickness of the strata above necessitates boring to a similar depth to reach the coal.

Materials from the outcropping strata are utilized locally, but the concealed strata will be exploited from the mines to develop new industries which will increase the trade of the port of the region. The chief of these industries will probably be the manufacture of iron and steel goods, since iron ore, occurring in part of the region at a depth of about 600 feet, and limestone, for a flux, can be obtained from the mines.

Although the region is one of moderate relief, its topography has a considerable influence on mining development. Chalk hills occupy most of the area, except in the north, where low hills of Tertiary sands border the alluvial flats of the Stour. The chalk ridges run north-eastwards, decreasing in altitude, and only near the Dour valley, unfortunately for Dover, do they impede communication. Excluding Chislet on the hills north of the Stour, the present working pits are located on the chalk downs. If mines are established on the Stour marshes, they will encounter drainage difficulties, but part, at least, of this area will be served by Ramsgate or Sandwich unless communications with Dover are improved.

Although several other pits have been sunk since coal was first proved to exist near Dover in 1890, there are at present only four working mines—Tilmanstone, Snowdown, Betteshanger, and Chislet—and it is with the trade of the first three of these and of new mines within its immediate hinterland that Dover hopes to deal. Tilmanstone and Snowdown produce good steam coal, already used for bunkering at Dover, and coal suitable for the extraction of by-products, such as gas, which Tilmanstone supplies to a large area. Much of the Betteshanger coal is used locally for household purposes, but is suitable for manufacturing.

Apart from the export of coal itself and the import of pit-props and other mining requirements, trade will be stimulated by new industries, which will be encouraged by the growth of the local market with its increasing population. There will be a growing export of manufactured goods and import of raw materials for industries, as well as an import of such manufactured articles as cannot be produced in the region, and of agricultural products to supplement local supplies. London will supply some of the necessary trade facilities, but development of the region will be hampered unless a local port is obtained. The suitability of Dover has been doubted to such an extent that the possibility of making Deal a port for Betteshanger colliery has been considered, and other suggestions have been made.

The port of Dover, the future of which is so uncertain, has, as is well known, the advantage of the shortest sea route to Europe—22 miles to Calais—accounting for its early importance for trade with Europe and for its present importance as a passenger port. Actually, shorter crossings exist: those from Dover to Cape Gris Nez and from the South Foreland to Cape Gris Nez or Cape Blanc Nez are shorter, but these exposed headlands offer no good harbour sites. The narrowness of the Channel gives Dover a second advantage, since it causes the convergence of world traffic to London and to the North Sea and Baltic ports of Europe; for this reason an increasing number of liners call.

The town is built where a small river, the Dour, breaks the chalk cliffs and

enters the sea in a wide bay, to which the headlands gave a sheltered anchorage before they were eroded by the sea. This estuary was used as a harbour by the Romans, but subsequently a delta was formed and has been reclaimed for building. The Dour and its long right-bank tributaries, of which the Alkham valley stream is now practically its only feeder, cut deeply into the chalk. As a result, the town is crowded into the main valley and extends up the dry valleys entering from the south-west. The steeply rising hills limit communication, except up the Dour valley and the coombes, and the north-eastern side of the main valley has no long coombes to offer easy routes. The Downs reach the sea in imposing cliffs over 300 feet high and offer convenient sites for forts; the Castle is situated on the East Cliff, and there are barracks on the Western Heights. The site of Dover is unique on the coast of East Kent, and here it is hoped to develop a port for the coalfield.

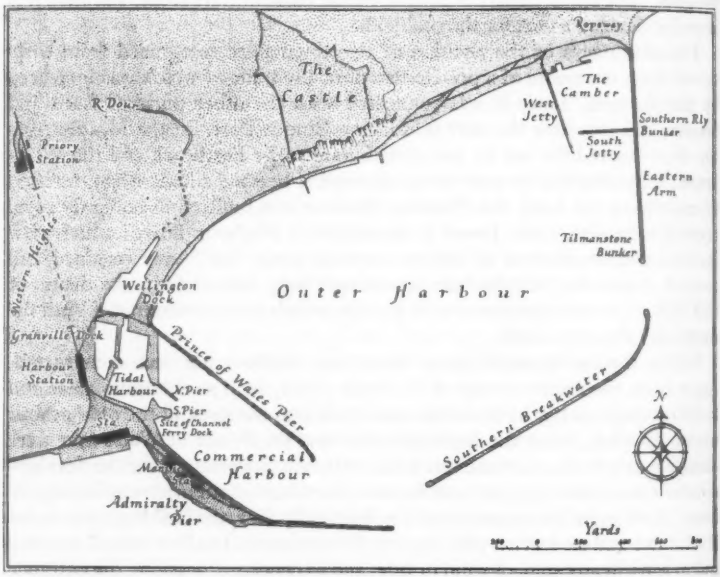
The advantages of the position of this town were recognized from early times: there are traces of a pre-Roman port, the trade of which was increased by the Romans. Later it was connected with the other ports of Kent and Sussex, and it is now the only flourishing Cinque Port. In the Middle Ages the river entered the sea by two distributaries, the Eastbrook and the Westbrook, of which the former was used until it became silted, when, assisted financially by the king, the Western Harbour was built. Subsequently royal control increased, until James I established a Harbour Board, which now includes representatives of Dover, but the town has never regained full control. From the Middle Ages the shingle bar, derived from the debris of cliff falls, was a continual source of trouble, which was not eliminated until the Admiralty Pier was built.

Within the last hundred years the modern harbour has been constructed. Apart from the improvement of the inner docks, such as enlarging gates and building quays, a big harbour has been built and encloses all the old harbour works. In 1896, when the Admiralty Pier and the Prince of Wales Pier were already partly built, a scheme was initiated by the Government for the development of Dover as a naval port and has now been carried out in almost its original form. It included the extension of the Admiralty Pier, the building of an outer breakwater and an eastern arm, leaving two entrances to allow vessels to enter and to leave at any state of wind or tide, and to choose, if possible, the entrance nearer their berths. The harbour was opened in 1909 and the Marine Station was built on a widening of the Admiralty Pier by the railway company in 1913. With these recent additions, Dover has the finest harbour in East Kent, and offers to the collieries the best facilities so far obtainable.

The port now consists of two parts, the older inner docks and the new Admiralty Harbour which was handed over to the Dover Harbour Board in 1923. The two innermost basins are the Wellington Dock and the Granville Dock, which communicate with the tidal harbour by lockgates, constructed to keep the water to a sufficient level for cargo vessels, and, in the case of the Granville Dock, for packet boats. The Tidal Harbour is entered by an open channel between two piers, known as the North Pier and the South Pier respectively, beyond which is the much larger commercial harbour, bounded by the Prince of Wales Pier and the Admiralty Pier. To the north-east, the Prince of Wales Pier, the Southern Breakwater, and the Eastern Arm enclose

the Outer Harbour, at present little used in proportion to its area, which is so large that it is used by cross-Channel seaplanes. It contains some smaller jetties of which the largest are the West and South Jetties cutting off a basin known as the Camber (see Map 1).

The three inner docks are very important for cargo traffic, for which there is good quay and warehousing accommodation. Some of the chief imports are textiles, skins and furs, grain, timber (including pit-props for the mines), Yorkshire and Welsh coal, and road-making materials. Of these imports, some, such as coal and timber, are sent as far as East Sussex. The exports are of less value than the imports. They include some entrepôt trade, especially of wool, which is the chief single export item by value, while the export of



Map 1. Dover Harbour

manufactured textiles is second, closely followed by the parcel post which is not sent from the inner docks. Modern mechanical equipment, run by electricity, is used to facilitate loading and unloading, and the quays are connected with the sea-front railway and thence with the main Southern Railway line.

The Commercial Harbour is used by cross-Channel boats which berth at the Admiralty Pier, on the lower inner side of which is the Marine passenger station. Liners berth on the north-eastern side of the Prince of Wales Pier, which has throughout its length a railway, crossing the Wellington Dock by a swing-bridge. The Southern Breakwater is not yet used for commerce, but may be utilized for the coal trade. From the point of view of the coalfield, the Eastern Arm is at present the most important. On its harbour side the depth of water

is always more than 26 feet, providing berths for fairly large vessels. At the outer end of the pier is a 5000-ton coal bunker, connected by an aerial ropeway with Tilmanstone colliery. The ropeway carries coal at the rate of 120 tons per hour, although it does this by no means continuously as yet. Upon arrival the coal is automatically tipped into the bunker and over 500 tons per hour can be loaded into ships, in such a way as to cause a minimum of dust. Nearer the shore on the Eastern Arm is the new coal-handling plant, built by the Southern Railway Company and supplied with Kent coal by an extension of the sea-front railway. Between this and the Tilmanstone bunker is a berth for vessels desiring to load or unload oil, using a pipe-line which runs along the pier to a Shell Mex installation beside the Camber.

Many of these facilities are not connected with the coal trade, but as the population and the industries of the coalfield area increase, the trade of the chief port will be increased, and it will be an advantage to have a port which has already some facilities for dealing with varied trade. The passenger trade alone neither has nor will have any relation to the development of the coalfield.

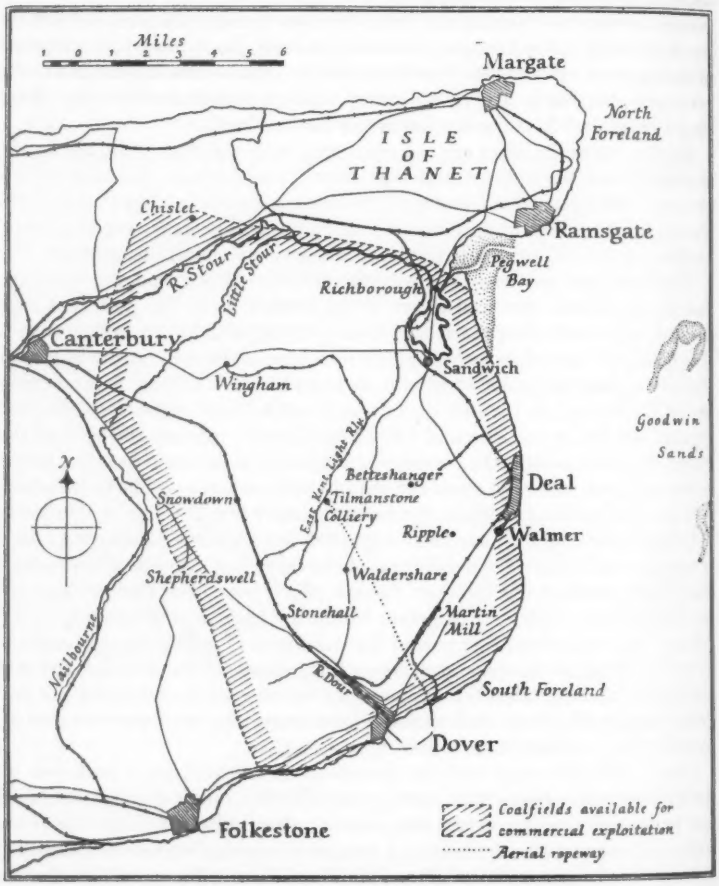
The interested parties—the town, the Harbour Board, and the Southern Railway Company—are well aware of the limitations of the port as it is at present, and many proposals have been put forward for its improvement. The Channel Tunnel, once begun, has now been given up, but the Southern Railway is about to provide train-ferries in its place. The work is proceeding on the ferries and on the new dock, which will be built between the Marine Station and the South Pier and will have sluices to regulate the level of the water. The ferries will take passengers, sleeping coaches from London, goods trains and cars, although there are already two car ferries. The train-ferries will cross to Dunkerque, where the docks are larger than at Calais or Boulogne.

Other improvements have been suggested, but Dover is hampered by lack of space, on account of the narrowness of the valley and the cliffs at the eastern and western ends of the harbour. Various efforts have been made to increase accommodation, such as reclamation within the harbour, the building of the Marine Station on the lower part of the Admiralty Pier, and the construction of jetties. By these expensive means very little extra space is obtained, and this will be one of the greatest limitations of the future growth of the port and one of the reasons why Deal, with its ample level space, may be of more value as an outlet for the coalfield than Dover.

Good communication with its hinterland is essential for a port, but at Dover the steeply rising hills cause great difficulty, much of which however has been overcome by expert engineering. One railway follows the Dour valley and then crosses the hills by a comparatively easy route to Canterbury, passing the pithead at Stonehall and the Snowdown colliery; but the line to Deal curves and tunnels and that to Folkestone tunnels. The greater part of the coalfield was not served by any railway until the East Kent Light Railway was built through the middle of the area; it passes Tilmanstone and has branches to the attempted collieries at Wingham and Waldershare. Its traffic is small as yet, although it collects agricultural produce as well as coal, and it generally runs only two passenger trains daily, connecting with the main line to Dover at Shepherdswell. Betteshanger has a special line to the main line near Deal, and only communicates with Dover *via* this town. By these rather

indirect routes the collieries of its hinterland have railway communication with Dover, and the East Kent Light Railway can be extended as new pits are sunk (see Map 2).

Unfortunately, within the town itself railway connections with the harbour are inadequate. The cargo traffic of the harbour and swift passenger trains,



Map 2. Communications in East Kent

from the Marine Station, meet the main line traffic near the old Harbour Station, and, in spite of recent improvements, congestion ensues and will be worse when the train-ferries start. The harbour railway has connections with nearly all the quays of the Inner Harbour and then extends along the sea-front to the Eastern Arm, by which means the Southern Railway Company sends Kent coal to the bunker. The sea-front railway was built for War purposes,

and it is not suitable for heavy coal traffic, apart from the delays which arise where it meets the line to the Prince of Wales Pier. It is not likely to be improved, since objections have been raised, with the increasing number of trains, to its use for coal at all, on the ground that the coal dust and noise are an annoyance to residents on the sea-front and to summer visitors, while the trains make the roadway dangerous. Proposals have been made to bring Kent coal to the Eastern Arm by other methods, such as by an extension of the Tilmanstone aerial ropeway to Betteshanger and Snowdown, by the construction of a tunnel from the main line at Martin Mill, where there is ample room for sidings, to the docks, and by the renovation of an old railway from Martin Mill to the East Cliff, if a means could be found to convey the coal down the cliffs. The scheme which is most likely to be carried out however is the construction of a tunnel from Deal junction, where the Deal and Canterbury lines meet in the Dour valley, and from which coal brought by both lines can be taken by the tunnel railway to the Eastern Arm. The chief objections to the tunnel are that it will be costly, since it will be some years before the traffic justifies it, that there is a lack of space for sidings for coal trucks, and that the unloading of trucks causes more dust than the unloading of coal buckets, and is more expensive, so that customers may be lost.

Much more satisfactory is the aerial ropeway, $7\frac{1}{2}$ miles long, which runs from Tilmanstone to the Eastern Arm, descending from the Downs by a tunnel which emerges on the cliff face. It began working in February 1930, and has solved for Tilmanstone the difficulty of reaching the coast (see Map 2).

The road connections between Dover and the coalfield are not important for coal, except locally, but will be used, when other industries develop, for the increasing number of commodities which are carried by road. The coalfield is crossed by a network of second-class roads, but these converge above the Dour valley and, as the few good roads entering the valley are already steep and dangerous, their number must be increased as traffic increases.

The communications between Dover and its hinterland are certainly an impediment to its trade as an outlet for the coalfield, and though they may be improved, as in the proposed tunnel scheme, the improvements are so costly that they will be avoided wherever possible. Although the port provides the best facilities obtainable at present, its lack of space is a disadvantage which might never be adequately overcome, and it might be more satisfactory to pay the larger initial expenses of opening a new port where extensions are possible. At Dover there will be little room to build factories or houses for an increasing number of industrial workers, and, since a port receives imported raw materials of large bulk, it is an economy to manufacture them there, if local sources of power, such as coal, are available.

Until the recently increased use of the sea-front railway for the export of Kent coal from Dover, much of the coal was exported through Queenborough, which has a fairly good railway link with the coalfield, but is so far from it that, although Queenborough has some facilities as a coal port, the Southern Railway Company has now decided to use Dover instead. The difficulties which immediately arose emphasize the need of some more suitable outlet if such can be found.

The north coast of East Kent is unsuitable for a port, as it is bordered by

very shallow water, except in the Isle of Thanet. However no port is likely to develop on the north coast of Thanet, because Ramsgate, south of the Foreland, has already a small harbour which could be used. Ramsgate on the north and Folkestone on the south of the coalfield are ports already established with a good depth of water and some harbour facilities. However neither could hope for nearly the whole trade of the coalfield, as, apart from the present inadequacy of communications, especially from Folkestone, neither town is centrally placed with respect to the region. Although Dover, in its recent agitation against the sea-front railway, claimed that it could be both a seaside resort and a port, it is doubtful whether either Folkestone or Ramsgate would gain sufficiently as a coal port to compensate for losses as a resort.

Between Walmer and Folkestone there are no large accessible gaps in the cliffs, except at Dover, so that the possible site for a port, apart from Dover, is limited to the coast between Ramsgate and Walmer, including Richborough, Sandwich, and Deal. Sandwich can be reached by barges at high tide, but the Stour is so shallow and winding that it would be better, instead of trying to improve the Stour as far as Sandwich, to use Richborough. The latter was used during the War for the terminus of a train-ferry to France, and many buildings were erected; at present most of these are deserted, although a few are inhabited and a few are used for factories, a purpose for which more might be utilized. The many disused light railway lines, built for War purposes, might be of value for a port, and there is plenty of room for extensions. The light lines are connected with the Southern Railway and with the East Kent Light Railway; and further connections by railway and road could easily be made to the coalfield, since there is no difficulty of approach as in the case of Dover. Unfortunately, the area is a drained marshland, and although supplying possible factory sites, it would not be a healthy residential district. The deepening of the Stour sufficiently for large vessels to reach Richborough, even if only at high tide, would be very expensive, and although vessels could safely wait in the Downs, the delay would be a great inconvenience. The mud-flats of Pegwell Bay provide no good foundations for piers, and would render essential the construction of long deep-water approach channels to Richborough.

Sandwich Bay is similar to Pegwell Bay, but at Deal the 5-fathom line approaches within 1 mile of the shore, as at Dover, so that it would not be necessary to construct excessively long piers or long dredged channels. Here is a most promising site for a port. The inshore waters, known as the Downs, are sheltered by the Goodwin Sands, an advantage which Dover lacks, and vessels taking this sheltered route could call without deviating much from their course. Deal is however cut off by the Goodwin Sands from the route passing through the Channel from the Baltic and North Sea coasts of Europe, while large liners to or from London generally go outside the Goodwins. Deal is largely built on a well-drained lowland, which offers plenty of space for factories and for housing an industrial population, an advantage which Dover cannot have. The town extends behind Walmer to the chalk, where many houses have been built recently for Betteshanger miners. If the new harbour is built north of the town, the factories could be beside the docks and away from the town itself. At present Deal has little communication with the coal-

field, except with Betteshanger colliery, but it is centrally placed, and this difficulty could be eliminated more easily than at Dover, as the hills are lower. The chief disadvantage of Deal as an outlet for the coalfield is that it has no harbour; its present pier is valueless as a breakwater, and the coast is too straight to afford any natural protection. Foundations for the harbour would be moderately good, although trouble might arise over the shingle drift from the Channel. A small harbour would not have sufficient facilities to attract trade from Dover, and it would be excessively costly to build a good one, resembling Dover harbour, which was built for naval purposes with national funds.

It appears then that Deal is the only formidable rival of Dover as an outlet for the coalfield, but the attitudes of the two towns towards the subject are very different. At present Deal has little industry and no trade, and all the industrial workers would have to come from elsewhere. The town has little interest in the prospect of its development as a coal port, but Dover is well aware that its prosperity depends upon its trade. It appears that the population of Dover has always varied with its trade and its recent growth has been connected with its harbour, so that in 1931 it numbered 41,095 people. Its trade has stimulated small local industries, such as the preparation of food, paper-mills, timber preparation, dye works, iron foundries, and ship-repairing. Some of these industries will be considerably encouraged by local coal and by the increasing trade of the hinterland.

Deal has ample space for extensive development but no harbour facilities and no ambition to develop trade, while Dover lacks space but already has good harbour facilities, a nucleus of industrial life, and better communications with its hinterland than those of Deal, although it has less possibility of extensions than the latter. To those who hope that the coal trade will become great and that the region will develop industrially, Deal is the better port site, but it is extremely unlikely that Deal will be used instead of Dover, except possibly as an outlet for Betteshanger, because the initial expenses would be too great, and there would be no immediate return since development of the coalfield will be slow. Already Dover receives Tilmanstone coal by ropeway and Snowdown coal by railway, and Betteshanger has begun to do the same as the latter. If it is decided to make Deal the port for Betteshanger, by building a small harbour, to be enlarged if necessary at a later date, two ports may grow; but the most optimistic cannot hope for sufficient industry to develop in East Kent to give enough trade for two great ports, and in all probability Deal would only have a coasting trade with Dover, the longer established of the two. It is this earlier growth, attracting an increasing volume of trade with the facilities already existing, that is really Dover's chief advantage over Deal. The coalfield lies mainly in that part of its hinterland in which Dover has hitherto been unrivalled and the only part that is likely to be industrialized, so that the town will endeavour to retain it. The advantages of Dover are so many that, although it is not as entirely suitable as an outlet for the coalfield as might be desired, it will probably be the major, if not the only, outlet, and it will, conscious of its great past, make every effort to overcome the disadvantages of the present, so that the resources of its hinterland can be developed unhampered and bring added prosperity to the industries and trade of the port.

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The Council have awarded to this Essay the prize offered for an Essay of not more than 5000 words: either a critical survey of recent additions to knowledge in a limited geographical field, or a discussion of some problem in its geographical aspect. The conditions are stated in Geogr. J., June 1933 (vol. 81, p. 576) and May 1934 (vol. 83, p. 443).

THE BRITISH GRAHAM LAND EXPEDITION

THE British Graham Land Expedition led by Mr. John Rymill will leave this country in the early days of September of this year. Fellows of the Society, which has contributed considerably to the expenses of the expedition, will look for some details of the projected plans and of their execution. Some description was given in *The Times* of March 7, and from time to time messages while the expedition is in progress and articles on their return will appear in that newspaper.

First, as to personnel. This will consist of fourteen. Mr. J. R. Rymill was with Mr. Watkins on his first expedition to Greenland, and took charge of the second expedition when Mr. Watkins was drowned in August 1932. Four of the first Watkins Expedition will go with him: Mr. Hampton, as air pilot; Mr. Riley, as meteorologist; Mr. Stephenson, as chief surveyor; and Surgeon Lieut.-Com. Bingham, R.N., as doctor; also two other naval officers. The Admiralty have shown their appreciation of the importance of the expedition by granting these officers full pay, and permission to count their time as active service. The Army Council has lent the services of a Signals officer, Lieutenant I. F. Meiklejohn, on similar terms. Mr. W. L. S. Fleming, now Chaplain at Trinity Hall, Cambridge, will go as geologist, the authorities having granted him permission to be absent. Mr. J. I. Moore will be one of the engineers, and he is perfecting himself in the conditions required by spending some time on Diesel engines in trawlers. Mr. Brian Roberts, who

has led expeditions both to Iceland and to East Greenland, will be surveyor and ornithologist. Mr. Bertram, of Cambridge, will be the biologist: he is at this moment in the Red Sea, and will therefore experience a pleasant change of temperature. An important member of the expedition will be Mr. J. H. Martin; Mr. Martin has twice been with Sir Douglas Mawson to the South, and has also had experience in Canada of arctic travelling. One other member has yet to be chosen—perhaps another naval officer.

A ship has been purchased, hitherto known as the *Navaho*. Her name will be changed to that of *Penola*, a name intimately connected with Mr. Rymill and his family in Australia. She measures 112 feet long and 24 feet beam, with a carrying capacity of about 200 tons. She was built in 1908 of two thicknesses of 3½-inch oak planking, and is a three-masted topsail schooner with a 100-h.p. Diesel engine, and a small deck engine for auxiliary work of 10 h.p. She is now being reconditioned and strengthened at Southampton to suit her for Antarctic conditions and for the accommodation of fourteen men. The outside is being strengthened by greenheart with strong iron doubling plates on the bow. Her two propellers, which are small, will have protection against the ice. An aeroplane will be carried, and it may be mentioned here that every advantage will be taken of modern science in the supply of instruments both for survey, for communication, and for hydrographical work; the seismograph is not being asked for only because it is not expected that very deep ice formations will be met with during the exploration. But otherwise no effort will be spared to gain experience. The aeroplane is a De Havilland Fox Moth capable of carrying three, or two with an Eagle III survey camera, and it is intended that both survey and reconnaissance should be accomplished from the air. On the ground dogs and sledges will be used. Sixty dogs are now being purchased by Mr. F. S. Chapman in West Greenland, which should be in England in the early part of this month. There will be about twelve sledges.

The house which will be erected at the base is of a new design: in two stories, of a double thickness of 1-inch pine planking, packed with insulation of a type not finally decided on. There will be nine bunks on the upper floor. The downstairs portion will be divided into three rooms—a wireless room, a dark room, and a general living room. The hangar for the aeroplane is attached to the house. The food will be practically the same ration as was used on Mr. Watkins' first Greenland Expedition, but it will be remembered that whereas in Greenland some supply could be expected from the country—seals, bears, salmon, etc.—in the Antarctic, once away from the coast, no such supply can be expected, and provision has therefore to be made both for dogs and men for the whole period of two and a half years.

Mr. Hampton and Mr. Stephenson with the dogs and a large portion of the equipment, including the aeroplane, will leave this country in July. Mr. Rymill and the rest of the crew will sail in the *Penola*, and all will meet at Port Stanley towards the end of October. It is intended that the *Discovery II* shall meet the expedition there and assist them in transporting the stores to Deception Island. From Deception Island the ship will proceed south. How far south she will be able to get depends on the ice conditions. If a safe position can be found for her, she will remain; if not, she will return to Deception

Island and carry out meteorological and hydrographical research there. In any case the party will divide into two, a shore party of nine and a ship party of five.

The final plans for exploration must of necessity be left very open and depend on what is found in the sector. The aeroplane will be rigged in Deception Island about the end of November, and a flight will be made over Bransfield Strait towards Graham Land. As soon as the ice is seen to be open enough the ship will proceed to Wilhelmina Bay on the west side of north Graham Land. From here it will be attempted to find a route across Graham Land to the east side by means of another aeroplane flight. If a possible sledge route can be found, a dog-sledge journey will be made down the east side of Graham Land, and if conditions are favourable a point near Foyn Island should be reached. This journey, though interesting in itself, will serve mainly to fill in time while waiting for the ice to break out along the south-west coast of Graham Land. The sledge party will return to the ship in Wilhelmina Bay and another aeroplane flight will be made south to ascertain the condition of the ice towards Marguerite Bay. When the ice is seen to be open enough, presumably about the middle of February, the ship will continue south and the party will try to establish a base as far south on Graham Land as possible or on Hearst Land itself. If a good wintering-place for the ship can be found as far south as this she will be frozen in for the winter. Here again the aeroplane will prove very useful in reconnoitring along the coast and between the islands to find a suitable wintering-place for the ship. As this will be in about 70° south it is quite probable that the coast-line will be too glaciated to allow of a good harbour being found, in which case the ship will return to Deception Island or perhaps to some harbour south of Deception Island, if one is found during the first summer.

When the base has been established, assuming that it is on Hearst Land, there will be no time left for journeys in the first season. It is impossible to plan a definite journey for the next sledging season as the country which it is hoped to explore is that lying behind the Weddell Sea, and since this is one of the greatest unknown areas in the Antarctic it will be impossible to work out the details for a sledging journey before a reconnoitring flight has been made with the aeroplane. It may prove to be part of the main Antarctic Continent, or Graham Land may continue as a series of islands for some distance; in any case the object of the first sledge journey will be to discover what lies behind the Weddell Sea. This should take up all the first sledging season, after which the party will again winter at its base. In the second sledging season another journey will be made to the west as far as the end of the Falkland Islands Dependency, which is 80° west. Here again it is impossible to give details of the journey as this area is also completely unknown. If time permits and the base is in a good position it is also hoped to make a journey northwards along the east side of Graham Land, and if possible to connect with the first journey which was made from Wilhelmina Bay. In 1937, when the ice breaks up sufficiently to allow the ship to work, the party will return home, arriving in England about May.

This is an expedition of importance, and indeed of national importance, for it is concerned with a sector of the Antarctic Continent claimed by this country

and is manned by men of this country. The Government have shown their appreciation by contributing £10,000 towards its expenses. Generous subscribers have been found in Lord Wakefield, Mrs. Patrick Ness, the Corporation of London, and Lord Leverhulme. We may assure Mr. Rymill and his companions, in the name of this Society, that we wish them well and look forward to their return. W. E. G.

THE EVOLUTION OF THE EARTH

DIE OROGENTHEORIE: Grundlinien eines natürlichen Gestaltungsbildes der Erde. By L. KOBER. *Berlin: Borntraeger* 1933. 9×6 *inches;* 184 *pages; diagrams and maps. M.*14.80

THE DEFORMATION OF THE EARTH'S CRUST: an Inductive Approach to the Problems of Diastrophism. By WALTER H. BUCHER. *Princeton (N.J.): Princeton University Press (London: Humphrey Milford)* 1933. 9×6 *inches;* xiv+518 *pages; diagrams and maps.* 22*s* 6*d*

THE two books here reviewed are in many ways very different from one another, yet both deal with similar problems. Kober's book is written to develop a theory; Bucher's volume, on the other hand, deals with theories—usually to upset them—and is concerned mainly with an analysis of the material upon which our knowledge of the Earth is based. He does well to point out how little is really known, especially about the ocean floors. In dealing with the evolution of the Earth it is certainly important to stress this negative side of our knowledge. Maps, whether physical or geological, often convey a very misleading impression. We have only to think of the many problems which still await solution in the physical geography and geology of our own country to realize something of what remains to be accomplished in the great continents, large parts of which are virtually unknown. Yet earth-theories by their very nature are based on this insecure foundation!

During recent years Professor Kober has written several books dealing with the evolution of the Earth and of mountain ranges. He is well known as an exponent of the nappe theory and has developed fully the notion of the squeezing out of a geosynclinal by the moving together of the rigid masses on either side. He is always interesting to read, and, to a foreigner, his books possess certain great advantages: they are concise and clearly written, and he does not obscure his meaning in long and involved sentences. The present volume is no exception. In it Kober discusses at some length the fundamental ideas of some of his earlier works. After a few preliminary chapters dealing with the evolution of orogenic and kratogenic (continental) areas, he sets forth his views on the dynamics of the processes involved in mountain-building. Then follows an interesting chapter on the evolution of the Tethys, which is followed by accounts of the Alpine and Variscan and other periods of orogenesis. The latter half of the book is concerned mainly with an account of the formation, according to his theory, of the continents and ocean basins. Finally, we have three chapters on the "Caledonian," "Variscan," and "Alpine" Earth.

It is rather difficult to avoid feeling that Kober is pushing his views too far, and only fair to suggest that the present volume should be read in connection with his other books; but this is not perhaps possible. The reader who comes first to this book will find that he is asked to assume a good deal, and if he is not

an expert stratigrapher he may find that he is apt to be carried away by the simplicity and speciousness of Kober's arguments. As with so many theories dealing with the history and evolution of our globe, simplification can easily be overdone.

Atlantic and Pacific stand to-day for certain characteristic features of the structure of the Earth. Kober admits this, but is at pains to point out that this was not so in the past. ". . . the Atlantic and Pacific design (*Bauplan*) of the earth only held good for the Mesozoic-Tertiary earth . . . and not, however, for the Palaeozoic earth which was characterized by other relationships—the geosynclines." Of the Pacific Kober writes that it is of continental design and shows orogens and kratogens. Its deep floor is similar to that of the continents: the lack of mass at the surface resulting from subsidence in the depths is compensated by *Simatisierung* ("injection" of sima), so that the same gravity relationships are observed in the Pacific as in the continents. The upper level of the sima, judging by his diagrams, is about 60 km. beneath the surface, but the process of sima formation under an orogenic mass seems to start at 45 to 50 km. beneath the surface.

Enough has been said to indicate that the student of earth-theories will find much to interest him in the book, and perhaps also a good deal he will want to dispute. This is as it should be. It is however a pity that no reference to Jeffreys' views appears in the book, and his name is not even mentioned in the bibliography. Although brief reference is made to earthquakes, it is unfortunate that a fuller discussion of the information obtained from seismological observations on the structure of the outer layers of the Earth is not given.

Bucher's is an interesting and well-documented volume which will be welcome to all who are interested in problems of earth-history and evolution. The author does not set out to give us a new theory: rather he reviews critically the data upon which so many theories are built. He formulates his views in a series of laws. These laws are rather in the nature of "theses"; in fact, as he points out in his preface, he was advised to use this word rather than law. But the laws are based on good reasoning, and although nothing infallible is claimed for them, and strong criticism is invited, we may regard them as something more than mere opinions. The author himself certainly does so, because he has drawn up also a series of personal views which he calls "opinions."

In discussing the several main topics which make up the bulk of the book, the author has taken pains to give reasonably full analyses of certain areas well known to him either through field-work or through geological literature. He has tried to keep away from undue use of technical terms which may give misleading ideas. Law 3 makes this clear: "In ground plan, the forms of crustal elevations and depressions represent two types. First, elevations and depressions which are essentially equidimensional (swells and basins), and second, others that show a distinct linear development with one horizontal dimension decidedly greater than the other (welts and furrows)."

Naturally a great deal of the argument turns upon isostasy, and it is important to stress that the author does not follow Airy's view regarding the "roots of the mountains." In the absence of written evidence on the point he quotes a letter from Dr. Greig which states that granite would melt before basalt. If this is so, then Airy's view, and all other theories based upon it, must be wrong. Bucher therefore assumes that a certain datum—about 60 km. beneath the surface—"marks about the level above which crustal columns are approximately of equal weight." Unlike Kober, but in general agreement with most other writers, he supposes a relatively thin (20–30 km.) layer of lighter, acid material beneath

the Arctic and Atlantic oceans, whereas the floor of the Pacific is made of heavy, basic material. Below this crust is the asthenosphere.

It is pertinent here to point out one or two ways in which Bucher differs from Kober's conceptions. Law 15 expresses one matter concisely: "During any limited period of post-Algonkian time, small compared with the whole geological record, some orogenic belts lay far from the edge of the continental platforms, and always the number of continental shores that were free from orogenic movements was much greater than the number affected by them." He also makes it clear that although Kober's general conception of orogens and *Zwischengebirge* (median-masses) is of considerable importance and interest to geologists, his (Kober's) views on the orogen on the west North American Cordillera are far from being in agreement with the details of structure as known to American geologists who are best acquainted with that area. Bucher's discussion of eustatic and other movements of the strand-line is interesting, but not so full, and perhaps not so convincing, as his treatment of mountain-building. He points out the inherent difficulties of the question of raised beaches and shows how they may be related to the Ice Age, and also to coral islands. He concludes however that eustatic movements are due to "changes in the vertical distance between mean levels of ocean floors and continental surfaces."

Clearly such a book as this should be a full epitome of all that has been written. That however is an impossibility. The author has an enormous grasp of the literature of the subjects relevant to his inquiry, but naturally is more familiar with certain sides of it. For example, in speaking of crustal shortening he does not refer to Jeffreys' view of the sliding forward of the Alpine "klippen" as a possible means of reducing the amount of compression required in mountain formation. Similarly, Holmes's views are treated all too briefly.

The general views of the author on one of the main subjects of inquiry in his book may be summed up in his own words: "According to the view here developed, the mobile zones originate as fracture zones under crustal tension. When the crust begins to suffer compression, overthrusting and folding become localized along these mobile belts, taking up the horizontal shortening of the circumference. As shrinking progresses the crust as here defined thickens to the extent that cooling is involved. The thickening of the crust results in an increase of crustal relief. This must involve a considerable amount of lateral transfer of matter below the crust."

The book is very well worth reading and should provoke thought and discussion amongst all who are interested in the Earth. It is clear in its treatment and is logically developed. It is not written in any dogmatic spirit, and the author strongly invites criticism; the final chapter summarizes his main views. Some of the illustrations are not very clear, but the book is well indexed, and the references to literature are generally excellent and up to date. J. A. STEERS

REVIEWS

EUROPE

OFF THE BEATEN TRACK IN SUSSEX. By ARTHUR STANLEY COOKE. New Edition. *London: Herbert Jenkins* [1932]. [First published in 1922.] $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 384 pages; illustrations. 6s*

This is a new edition of a book which has gained merited popularity. Its plan is to take the reader rambling over country paths; there are numerous and pleasing illustrations in black and white. The book covers a great deal of ground both geographically and in subject-matter, and is very cheap at six shillings. It is for the armchair, to be digested at leisure, rather than for the car or the hiker's pocket. The author writes easily, almost garrulously, with humour and zest, enjoys nearly all he sees, and has a sympathetic understanding of small and humble things met by the way. Naturally he lays no claim to being exhaustive. The title, of course a relative phrase, is not to be taken to mean that most of the things described are rare: indeed the text is largely a rechauffé, lively it is true, of what has been said many times in a score of Sussex books. But on this count the reviewer is disarmed by the author's "I do not apologise for pointing out the obvious." Still one wonders why the north-western part of the county between the Western Rother and Stane Street, the comparatively remote region of Billingshurst, Petworth, Wisboro', Kirdford, Loxwood, and Plaistow, gets no treatment at all.

For a new edition the book contains a fair crop of mistakes. Thus, to mention a few at random, we have the White Hart instead of the White Horse at Steyning, Gumworth for the well-known Down farm of Gumber, and Ashfoldean for Alfoldean, near Slinfold. Chanctonbury Ring, probably an Early Iron Age enclosure, is said to have been used as a Roman stronghold, whereas it sheltered a Gallo-Roman temple and two related buildings. The almost certainly Danish earthwork at Burpham cannot be assigned to the Romans. Why assume that a Roman villa at Wiston was a guardhouse for Roman soldiers, and that Stane Street started at Bracklesham Bay? The famous Shipley reliquary is not at Shipley, but has been kept at the Victoria and Albert Museum for several years past. In matters antiquarian, at least, the reader who probes at all deeply will find many similar lapses. It is of course hard to assess the degree of accuracy to be expected in pleasant topographical books of a discursive character; but a little revision for a new edition might have been expected. S. E. W.

RUSSIA: U.S.S.R.: A Complete Handbook. Edited by P. MALEVSKY-MALEVITCH. *New York: William Farquhar Payson* [*London: Williams and Norgate*] 1933. $10 \times 6\frac{1}{2}$ *inches;* xvi+712 *pages; maps.* $10 (£2 2s net)

Unlike most books about present-day Russia, this one is concerned almost entirely with facts. There is no attempt to convey atmosphere, to interpret psychology, or to draw conclusions. The authors are mostly Russians of the pre-revolutionary intelligentsia, now living abroad. Among them are university professors and publicists, a member of the old Council of Empire, a war-time Minister of Education, and a Minister of Finance in the Provisional Government. Their point of view is that of the moderate, liberal bourgeoisie, and is generally critical of the standards reached under the Soviet régime. The treatment is not therefore colourless, but neither is it propagandist. It can fairly claim to be objective. The sub-title, 'A Complete Handbook,' is also no misnomer. There are chapters on every branch of political, economic, and social activity. One of the most useful features is the description in each case of conditions before, as

well as since, the Revolution. Any one about to visit Russia, or to embark on Russian studies, would start with a nucleus of sound information upon which to build his personal appreciations and judgments if he mastered the contents of this volume. J. de V. L.

ASIA

CHICAGO DER WÜSTE. By HANS HELFRITZ. *Berlin: Reimar Hobbing* 1932. $9\frac{1}{2} \times 6$ *inches;* 176 *pages; illustrations. M.*6.80

This book, with its excellent illustrations, is the result of a visit to the Hadhramaut, still largely a closed land to European travellers. The author, who received permission for the journey from the Sultan of Mukalla, apparently visited the country in 1931 or 1932—he is sparing throughout of dates and details—without much equipment for an arduous undertaking. Joining a caravan, he was able to visit the great interior valley of the Wadi Du'an, and the remarkable towns of Saiwun and Shibam. Their striking characteristic is the tall many-storied building, not unlike "skyscrapers," to which the book owes its unhappy title. The numerous photographs, excellently produced, of these buildings and their surroundings justify the risks and hardships the author underwent; the style of the text is not worthy of them, and further details of the history and construction of these architectural curiosities would have been welcome. G. R. C.

MINYA GONGKAR: Forschungsreise ins Hochgebirge von Chinesisch Tibet: Erlebnisse und Entdeckungen. By ARNOLD HEIM. *Bern—Berlin: Hans Huber* 1933. $9\frac{1}{2} \times 6$ *inches;* 244 *pages; illustrations and maps. M.*8 (*Fr.*9.80)

When Dr. Heim was leading a geological party through Szechwan in 1929 he was intrigued by glimpses of great snow-peaks to the west, and determined to visit them at the first opportunity. Despite civil commotion and financial difficulties he was able to organize, under the auspices of the Sun Yat Sen University at Canton, a geological expedition which set out the following year. This book is the record of that expedition, mainly intended for the general reader, though interspersed with acute observations on the geology, plant life, and anthropology of this interesting region. It is accompanied by a liberal selection of excellent photographs which alone justify the publication.

To avoid the wet summer season, which has hampered previous travellers in this region, and retarded a knowledge of the mountains, Dr. Heim planned to spend the winter of 1930–31 on the Chinese–Tibetan border. After vexatious delays at Yunnan-fu his party, accompanied by a Chinese escort, safely traversed the brigand-infested area to the north, crossed the sparsely peopled Yangtze–Tung-ho divide, and reached Tatsienlu by the main caravan route.

The main interest of the surrounding mountain region is the great peak, Minya Gonka, or Bo Kunka, once erroneously alleged to rival Mount Everest. From time to time in this *Journal* reports of travellers upon it have been recorded and analysed. It will be remembered that it was considered very unlikely that its height exceeded 25,000 feet (*Geogr. J.*, April 1930, p. 345). Dr. Heim, who had with him a Swiss topographer and a Wild theodolite, was able to travel round the massif, though continual bad weather prevented close study. He gives its height as 7700 metres (25,200 feet), and publishes the first detailed map on a scale of 1 : 275,000. No details are given of the altitude determinations, except that they are based upon aneroid readings. R. L. Burdsall, of the American party, who used a mercurial barometer to determine the height of their base camp, calculated the height of Minya Gonka to be 24,891 feet, with a probable error of ± 85 feet (*Geogr. J.*, February 1934, p. 168).

He had hoped to continue his journey much farther westwards, aiming ultimately at Sadiya in Assam, but the conditions obliged him to abandon even the limited objective of Batang. Instead, he travelled north-west through little known country to Kanze, obtaining good views of Jara, whose height he gives as 5900 metres (19,300 feet). He also visited the earthquake area of Tao-fu.

A pleasant feature of the book is the evidence it affords of the cordial relations existing between missionaries of various denominations in this out-of-the-way borderland, and the willing assistance they afforded the traveller. On his later journeys he was accompanied by Mr. J. H. Edgar, whose interest in these marches is well known. This book will rank high in the literature of travel on the Chinese-Tibetan border. G. R. C.

AFRICA

SHIPS AND SOUTH AFRICA: a Maritime Chronicle of the Cape, with particular reference to Mail and Passenger Liners from the early days of steam down to the present. By MARISCHAL MURRAY. *Oxford: University Press* 1933. 10×7½ *inches;* xxvi+360 *pages; illustrations.* 35*s*

This book is in two parts, the first being a history of steam navigation to South Africa from the year 1825, when the *Enterprise*, the first steamer to enter Table Bay, called there on her voyage to Calcutta. Particulars are given of the early pioneers which included many famous vessels such as the *Great Britain* in 1852 and the *Argo* in 1854. The latter in the previous year had been the first steamer to circumnavigate the globe. In 1853 the Union Steam Collier Company was founded, which, reorganized in 1856 as the Union Steam Ship Company, sent out their first steamer, the *Dane*, in the following year. The Union Line successfully held its own against competition until 1867, when the discovery of diamonds led to a great increase in South African shipping and to the advent of Donald Currie, who sent out his first chartered ship, the *Iceland*, in 1872; the first of the famous "Castles" to visit Capetown, the *Walmer Castle*, arriving later in the year. From this time there was great rivalry between the two companies until it was ended by their amalgamation under the name of the Union Castle Mail Steamship Company in 1900. Three chapters tell the story of the part taken by South African shipping in the Great War, while two others give accounts of shipwrecks and disasters. There are references to several interesting episodes, such as the commission of the Union liner *Moor* as an armed merchant cruiser during the Russian scare of 1885 (for a fuller account see *The Navy*, 1913); the presentation at Port Elizabeth in 1895 of a Transvaal flag to the Bucknall steamer *Johannesburg* by the Landdrost of the city after which the ship was named, and the only "naval action" of the Boer War, when a commando under Hertzog reached the coast at Lambert's Bay and was shelled by H.M.S. *Sybille*.

The second part is in two sections, the first, entitled "The Shipping Lines and their Story," being an account of fifty-six British and foreign companies engaged in the South African trade. The second section gives historical notes on 190 vessels in alphabetical order which have belonged to the Union, Castle, and Union Castle Lines. The author does not mention a fact of interest to geographers, that Shackleton served as an officer for two years (1899–1900) in the *Tantallon Castle*, *Tintagel Castle*, *Gaika*, and *Carisbrooke Castle*. The launching of the *Windsor Castle* by the Prince of Wales in 1922 was not "the first occasion" that a member of the Royal Family had "taken part in the launching" of a merchantman, as King James I was present at the launch of the *Trades Increase* in 1609, and the Prince Consort acted as sponsor to the *Great Britain* in 1843.

A notable feature of this book is the 332 illustrations, of which all but two are

of steamships. Some mariners might perhaps think that "Steamships and South Africa" would have been a better title, as a similar volume could well be written on the part taken by sailing ships in the history of South Africa. The work contains six appendices with two indexes, and has been admirably produced at a very reasonable price. J. W. D. P.

THE SOUTH AND EAST AFRICAN YEAR BOOK AND GUIDE. Edited by A. SAMLER BROWN and G. GORDON BROWN (for the Union Castle Mail Steamship Company). Fortieth Edition, 1934. *London: Sampson Low, Marston & Co.* (1934). $7\frac{1}{2} \times 4\frac{1}{2}$ *inches;* lxiv+1126+64 *pages; maps.* 2*s* 6*d*

The 1934 edition is the fortieth of this valuable book edited for the Union Castle Mail Steamship Company. It may be bought for a remarkably modest sum and the purchaser, be he traveller, settler, or student, will find its eleven hundred pages full of widely varied information, grouped under subjects or under countries, ranging from history to land, from banks to mining laws, from big game to locust pests, from diseases to air-mails, while the prospective settler on the land will learn much about labour problems, farming in all its branches, acquisition of land, etc., and the commercial settler as much in his own line in the "Desk Section," so named and new to the present edition.

It is however in all probability the traveller who will derive the most benefit, and few in these days when Africa is intersected not by tracks but by roads, will search in vain for a description of his route and destination or for notes on any subject on which he may require enlightenment. When, as a test of up-to-dateness, the present reviewer looked for a new East African motor road travelled for the first time in the latter part of 1933, it was mentioned, though it could scarcely have been completed when the volume went to press.

This is a guide which the reviewer feels confident of recommending for general accuracy from long familiarity with its contents. The Atlas is by Messrs. Bartholomew & Sons, Ltd., and consists of some three dozen admirable maps, some of which have been specially drawn. E. W. N.

TANGANYIKA WITHOUT PREJUDICE. By ERIC REID. *London: "East Africa"* 1934. $7\frac{1}{2} \times 5$ *inches;* x+240 *pages; sketch-map.* 5*s*

In his short foreword to this slender but comprehensive volume Sir Stewart Syme (late Governor of Tanganyika Territory) points out that it contains not only useful information and instruction but opinions which may not perhaps be shared by all. Its opening chapter consists of a review of the territory's history, including naturally the years under German rule, and here at once the author emphasizes his firm belief that the British "mandate is as permanent as the British Commonwealth," disbelief in which he hopes to dispel, a disbelief which has undoubtedly prevented and still prevents capital being invested in the country, as the reviewer found when visiting it a few months ago.

The author has a love for this particular part of Africa, where for many years he made his home. His observations are thus first hand. His object is to convey the true atmosphere of the land he loves. If one can judge by the order in which he deals with his subjects, big game claims his particular interest. The notes on this are interesting, especially as to the possibility of outfitting in Tanganyika instead of in Kenya. His sympathy is with the photographer. Sport as part of the life of the territory, from football to mountaineering, is dealt with. So is travel, in great detail and by all forms of transport, even to a twelve-day motoring itinerary, which would take the tourist to all the chief points of interest in the country.

The question of the native is treated with sympathy. So also is that of the

missionary, the author acknowledging his admiration and his belief in his fitness as an educationalist for the native. Coming to the question of German settlement to-day Captain Reid considers that dislike between British and Germans is dying out chiefly owing to British official courtesy and unofficial sportsmanship. There is much indeed to interest the general traveller, the gold-digger, the merchant, and the settler, even the domestic budget being worked out for the benefit of the new-comer. And when in doubt as to the locality described the reader may turn to a small but clear map.

This light and inexpensive volume is published by *East Africa*. E. W. N.

CENTRAL AND SOUTH AMERICA

THE CONQUEST OF THE MAYA. By J. LESLIE MITCHELL. *London: Jarrolds* 1934. $9\frac{1}{2} \times 6$ *inches; 280 pages; illustrations and sketch-maps.* 18*s*

The title of this volume may be regarded as a misnomer, for only the last twenty pages deal with the overthrow of Maya cities and civilization by the arms of the Spaniard—the one known conqueror. Preceding pages are occupied by the author's effort to do what has been not infrequently attempted previously: to build up from the existing evidence a history of perhaps the strangest of definite American cultures.

But, according to the common experience of every one who, fascinated by the problem of this remarkable enclave, has formed an acquaintance with the accounts of such early Spanish observers as Sahagun, De Landa, and Cogolludo, with such misty legends as are provided by the Popol Vuh and the several "books of Chilam Balam," and has also utilized the recent careful scientific studies of competent social anthropologists, it is not always easy to see the wood for the trees. And, in spite of much commendably hard work, Mr. Mitchell seems to have been overcome by this familiar trouble. He has been further handicapped by knowing nothing at first hand of the country about which he writes. In the circumstances it is scarcely surprising that he has readily adopted the long-discarded ideas of De Waldeck and Le Plongeon, who, a century ago, gazed upon the startling Maya ruins with the same "wild surmise" that led the late Lord Kingsborough to try to prove the identity of the Aztecs with the lost tribes of Israel.

Bibliography and index are scanty; spelling and accenting so peculiar that one wonders what happened to the proof reader. L. E. J.

AUSTRALASIA AND PACIFIC

DER EYRE-SEE UND SEIN BECKEN: von der Sächischen Technischen Hochschule zu Dresden genehmigte Dissertation. Vorgelegt von MARTIN REINHARDT 1932. *Verein für Erdkunde zu Dresden.* $9 \times 6\frac{1}{4}$ *inches;* iv+131 *pages; diagrams and map*

The author of this thesis undertook to present as finished a picture of Lake Eyre and its basin as accords with our present geographical knowledge. By basin he means not the drainage-basin of Lake Eyre but the tectonic depression at the bottom of which the lake lies. He does not say that he has visited the region, but he has visualized it so clearly that his account reads like an observer's record. Close attention however leads one to suspect that he has never been there; and the conclusion that he compiled the whole work seems unavoidable when it becomes apparent that he adds nothing to our knowledge of the depression but a diagram of isobaths for the part of the Great Artesian Basin which overlaps it.

Nevertheless, a compilation so complete and compact as this one is fit for use either in the library as a monograph or in the field as a handbook. The actual information is definite, correct, and well presented. Some of the author's judicial opinions however are more cleverly than wisely expressed. To decide that isostasy is a condition of the depression, before anything is known of the value of gravity within and around it, is premature. When the Australian geologists have learnt more about the Great Artesian Basin they will choose for themselves, no doubt, between the meteoric and the plutonic hypotheses of the origin of the water. The low pastoral capacity of the depression might, as the author believes, be slightly increased by railways laid from Marree, South Australia, into New South Wales and Queensland. But his own analysis of the working costs of the Central Australian Railway is enough to show that railway development in such arid country is not yet economical. M. A.

GENERAL

CHARLES DARWIN'S DIARY OF THE VOYAGE OF H.M.S. *BEAGLE*. Edited from the MS. by NORA BARLOW. *Cambridge: University Press* 1933. $9\frac{1}{2} \times 6$ *inches;* xxx+452 *pages; illustrations and maps.* 21*s*

Darwin's 'Voyage of the *Beagle*,' Wallace's 'Malay Archipelago,' and Bates's 'Naturalist on the River Amazon,' are perhaps the best known and most read of all the books of travel published during the early part of the nineteenth century. They were all the work of men who, as a result of their observations, contributed to the doctrine of Evolution, though in this respect Darwin's share was undoubtedly far the greatest, and he himself has acknowledged that 'The Voyage of the *Beagle*' "has been the most important event in my life and has determined my whole career." Darwin was only twenty-two in the summer of 1831 when the offer to accompany Captain Fitzroy came to him. He had shortly before left Cambridge after a creditable, but not particularly distinguished, career, very uncertain of his future, though he had in fact almost decided to enter the Church. When Captain Fitzroy's offer came to him his father was much averse to his accepting it, and it was his uncle Josiah Wedgwood who finally decided him to do so.

The diary as here printed is contained in eighteen little pocket books in which Darwin made the first rough pencil notes of his observations and impressions during his five years of travel. It formed the basis of the well-known 'Voyage of the *Beagle*,' which was first published in 1839 as the third volume of the official 'Voyages of His Majesty's Ships, *Adventure* and *Beagle*,' edited by Captain Fitzroy. The demand for the third volume immediately much exceeded the others, and it was reissued twice; finally a second edition was published by John Murray in 1845 under the title 'Journal of Researches into the Natural History and Geology of the Countries visited during the Voyage of H.M.S. *Beagle*.' This has been frequently reprinted since that date. The manuscript diary is now in the possession of Professor Charles Darwin. A typescript copy was made in 1891 by the late Mr. Horace Darwin, and it is from this and from the original that the present volume has been prepared by Mrs. Barlow, a daughter of Mr. Horace Darwin. It does not contain the scientific observations made during the voyage as these were recorded in separate notebooks, but is a record of his daily life while on board the *Beagle* and of his many land excursions, especially in Argentina and Chile. In reading the journal one is constantly struck by the terrible discomforts of a voyage of this sort a hundred years ago. The accommodation provided for him on board was very restricted. He had to sleep in a hammock, and his cabin was hardly large enough to hold both it and

his books and clothes; here he lived for nearly five years except when making excursions on shore. In addition he suffered terribly from sea-sickness, which he never completely conquered.

It has always been stated that Darwin's evolutionary beliefs were first started by his observations and experiences in the Galapagos. It is well known that when he left England in 1831 he had an unshaken belief in the immutability of species and the creationist point of view, and that in 1837, less than a year after his return, he was convinced of the transmutation of species, and began to seek the causes and the laws of the changes. Yet the only sentence in the Diary concerning the Galapagos which bears on this matter is as follows (p. 337): "I industriously collected all the animals, plants and reptiles from this Island [Charles I.]. It will be very interesting to find from future comparison to what district or 'centre of creation' the organized beings of this archipelago must be attached."

The volume is illustrated with the reproduction of a very charming pencil drawing of Charles Darwin as a young man. It was probably a preliminary sketch for the water-colour drawing of 1840 by George Richmond, and was found quite recently by Professor Seward in a cellar of the Cambridge Botany School. In addition to the preface and a biographical list of the persons appearing in the pages of the diary and some interesting notes bearing on the voyage from other sources there are two maps and a plan of the *Beagle*. We must feel most grateful to Mrs. Barlow for the care and skill with which this interesting and most revealing diary has been edited. W. L. S.

A MILLION MILES IN SAIL: being the Story of the Sea Career of Captain G. C. Dixon. By JOHN HERRIES MCCULLOCH. *London: Hurst and Blackett* 1933. $8\frac{1}{2} \times 5$ *inches; 256 pages; illustrations.* 12*s* 6*d*

Captain Dixon first went to sea as a child in the *Vaughn*, a 900-ton barque commanded by his father and sailing from Liverpool to Valparaiso in the year 1881. As master, he left the four-masted barque *Elginshire* in Liverpool in October 1919, thus completing nearly forty years in sail. His experiences are of particular interest in that they were gained in the period following the heyday of the clipper ship which was so fully and so splendidly dealt with by Captain Andrew Shewan in his 'Great Days of Sail.' Captain Dixon's book is a worthy follower in the same tradition, although it lacks something of the thoroughness and completeness of Shewan's work. It gives nevertheless a valuable insight into the life of the big windjammer of later years and the way she was handled, right up to the last days of the war, which will undoubtedly make it rank as a valuable and permanent addition to the literature of the sea.

Captain Dixon's descriptions are exceedingly vivid, particularly his account of his first ascent of the rigging, when he was sent aloft to overhaul and stop the gear on the royal. He has also introduced a number of useful observations: data concerning the height and length of seas; a chapter on the Sargasso; remarks on icebergs; and notes on the bottle-paper records which he kept for fifteen years for the United States Hydrographic Office. Some of his bottles made remarkable voyages. One, for example, of which he gives details, set adrift off the coast of Brazil in 1910, was washed ashore on the South African coast in 1921.

It is a pity that a book so full of interest should begin in a rather disappointing way, and the first few pages are moreover difficult to follow. Not enough information is given to enable the reader to understand why a sailing ship, handled by so experienced a master mariner as Captain Dixon's father, should, after leaving Liverpool bound out by the St. George's Channel, be forced so near the Irish coast by a south-easterly wind hardening to a gale that she had to anchor, being

uncertain of her position, her crew eventually having to cut away the masts to save the ship. Admittedly, as young Dixon was a child at the time, his recollections may not be clear now. But one wonders why, with the wind that way, the *Vaughn* could not either escape into the Atlantic or run back into the Irish Sea. Some explanation is needed, and none is offered.

The illustrations, for the most part, are not up to the standard of the text. Some of them have been heavily retouched by the blockmakers. The book however can be confidently recommended as a most absorbing record of the later days of sail. F. G. G. C.

THE MEANING OF ANIMAL COLOUR AND ADORNMENT. By Major R. W. G. HINGSTON. *London: Edward Arnold & Co.* 1933. 9×5½ *inches;* 412 *pages; illustrations.* 18*s*

This book may be briefly described as an unstinted extension of the familiar theory of apasematic or warning characteristics in animals. As a concrete illustration to justify and explain this extension the author selects the lion. Major Hingston believes that rival lions threaten and frighten each other by displaying their black ear-patches and tail tufts as they advance to mortal combat. But we are unacquainted with any evidence that this is so; and the idea is open to the criticism that the ear-patches and tail-tuft are quite well developed in lionesses, which seldom fight. The mane, too, of the lion is claimed to be acquired for the same purpose; but this growth comes into precisely the same category as the elbow-tuft and belly-fringe which are invisible to two lions facing one another, while the thick fringe of mane in front of the ears must conceal their black patches from the head-on view. We have dealt with the lion at some length owing to the prominence given to it as "a leading case." But following the lion comes the wolf, and for this animal it is claimed that the function of the black spot on the upper side of the tail is to frighten a rival when the tail is lifted. Here again there is no evidence. But this spot is well known to some zoologists to be a feature common to both sexes of most species of the dog family and to overlie a scent gland similar to glands, often associated with black hairs, found in other mammals, sometimes on the feet. It is moreover only conspicuous, as depicted in Major Hingston's caricature-sketch, in wolves with comparatively pale tails; and it seems most unlikely that a wolf, granting it perceives such a spot at all, will be startled in combative mood by its apparition, when familiar with it on the pendulous tail from behind on other occasions.

Clearly the lion and the wolf were not happy selections as introductory instances to elucidate the new theory of animal markings. The rest of his treatise embraces the greater part of the animal kingdom. One or two additional cases may be cited to justify the reviewer's position. It is well known that some colours, especially red, become fugitive in some birds kept in captivity, the rosy flamingo, for instance; generally, and not without reason, this is assigned to lack of some particular food. But Major Hingston ascribes it (in the case of the oyster-catcher's legs, for example) to the needlessness of a threatening colour accompanying the decline of the combative spirit. Birds however, like other animals, do not lose in captivity whatever combativeness they naturally possess; they become fearless of man; but that is a very different matter. He also states that antlers are branched to make them look more formidable weapons. There is very little doubt that the tines act as guards, preventing rival stags seriously injuring one another. Finally, few will agree with his belief that dancing fireflies are threatening each other with their shining lamps. The author must forgive the reviewer for saying that he too often states matters of opinion, such as those above discussed, as though they were facts. R. P.

RASSENKUNDE UND RASSENGESCHICHTE DER MENSCHHEIT.

By EGON FREIHERR VON EICKSTEDT. *Stuttgart: Ferdinand Enke* 1934. $10\frac{1}{2} \times 7$ *inches;* viii+936 *pages; illustrations and maps.* *M.*72.50 (*Bound,* *M.*76.50)

This very complete and magnificently illustrated work aims at a general exposition of the different types of man and especially of existing races from two points of view, first classification on the basis of bodily form, and secondly their history, migrations, and relation to present and past environment. This involves not only a consideration of the problems which are usually included within the sphere of the anthropologist but also a study both of present-day geography and of geographical conditions in former times, in fact, a study of the world at various times "als Lebensraum der Hominiden," a point of view which is particularly well illustrated by a series of most usefully compiled original maps; unlike most works on the races of man we find here pictures not only of the various types of man himself but also of his environment. The data on the living man himself are clearly given at the heading of each section, and include the number of persons measured, the cephalic index and stature, followed by a general discussion. The references, of which in a work of this size there must be a very large number, are given in the form of footnotes to the sections themselves, and should be easy to find one's way about in, but there appear to be a number of misprints in English names which it is hoped may be corrected in a future edition.

It would be easy, but unfair, in a general work to criticize details, but one or two points seem to stand out. It is a pity that the author has not given more attention to the work of the Biometric school, especially in regard to the collection of scattered data about skull measurements. The pages of *Biometrika* have in the last few years contained a large number of tables which include in a convenient and readily available form material which is otherwise very difficult to find. Whether one believes or not in the methods whereby these tables are compiled, they form an almost complete source for the cranial measurements of mankind, and should therefore save the student who desires such data a great deal of trouble. Further, since the pages of *Biometrika* are considered somewhat arid reading by many human geographers, it is of special importance to refer to these tables.

Although reference is made to crania, the greater part of the book lays especial emphasis on the living, and there does not appear to be sufficient correlation between the two types of evidence. It would seem of special importance where racial history is being studied that particular emphasis should be laid not only on the living persons but also on the cranial types of past periods, and that measurements both on the living and the dead should be given. The section on the Basques, for instance, omits to show the relationship which crania bring out between the Basques and the Franks. Again, there is no more striking example of racial history in a single country than the changes which have taken place in England since Neolithic times, but to emphasize these changes cephalic indices and profiles of skulls are necessary. How far these changes are due to changes of environment or advance in culture in the neighbouring regions is a question which falls well within the scope of Dr. von Eickstedt's book, and it is only right to add that it is by no means entirely omitted.

In spite of such criticisms, however, the book as a whole should prove a real stimulus to all students of human geography both for its encyclopaedic learning and for the breadth of scientific sympathy which it displays. L. H. D. B.

THE MONTHLY RECORD

THE NEW ORDNANCE SURVEY MAGNETIC MAPS OF GREAT BRITAIN

The Ordnance Survey Physical Maps of Great Britain are published in two sheets, one for Scotland and one for England and Wales: they show water in blue and relief by colouring. The names on the map refer to physical features only. A Magnetic Edition of these maps is issued from time to time, the latest being dated 1933. These maps give the value of the magnetic declination at a large number of points (about 150 on the map of England and Wales) where observatory or field observations have been made in recent years; the original observations have been corrected for the effect of the secular change so as to apply to the middle of 1933. In the previous edition of these maps, for 1928, the name of each such magnetic station was placed alongside the magnetic figure: these names are (rather regrettably) omitted from the 1933 edition. But a much more striking change of practice is made in the new edition, relating to the isogonal lines, that is, the lines along each of which the declination has one and the same value at all points. The 1933 map gives such lines for each whole degree of declination (11° to 17°), instead of for every ¼°, as in 1928; and the 1933 lines are nearly straight, and thus widely different from those of 1928, some of which were extremely twisted. A partial explanation of the change is given on the new maps, in the following words:

"The Isogonals, or Lines of Equal Westerly Declination (Magnetic Variation), show the underlying regularity of the distribution while the observed values, printed for each station where observations have been made, show the degree of approximation which is to be expected between values interpolated between the lines and actual values. The shaded areas are the principal areas where, owing to the occurrence of magnetized rocks at or near the surface, much greater anomalies are probable. No attempt to draw isogonals in these areas is of use. There are many small isolated areas coming into the same category but not shown. In such areas two points within a few yards of each other may show a difference in Declination of many degrees. The small departures from regularity in the Isogonals drawn do not indicate the true course of the lines, but serve to draw attention to anomalies in their vicinity. The present rate of change of Westerly Declination in England is about 10′ or 11′ per annum, *i.e.* a diminution, being slightly more rapid in the north than in the south. This rate of change is itself likely to slow down in the near future."

The small departures from regularity in the isogonals, as drawn, consist of breaks in the nearly straight continuous line of an isogonal, where the line is omitted altogether, or where it is drawn in broken form to one or other side, so as to go round an isolated station whose declination would otherwise correspond to the wrong side of the isogonal. This concession to the observations is interesting in view of the generally draconic mood in which these isogonals are drawn. In the previous maps outstanding observations were effective in diverting not only one but several isogonal lines out of an otherwise smooth course; the observations, as it were, beckoned the lines this way or that, and their call was heeded. On the new map a deaf ear, or a blind eye, is turned towards these beckonings, and the isogonals stride headlong across the country; yet conscience doth make cowards of them all when their bold march would actually place a sheep among the goats, or in other words, when the straight course of the isogonal

would leave an observation on the wrong side of the line. Hence the line is broken here and there.

The difficulties which the observations present to the map-maker are evident, and no simple solution of them is possible; but it does not seem to the writer that the solution now adopted is the best: deflections quite as large as those actually made at certain points along the isogonals could with equal justice have been made elsewhere along them. The fact is, there seems to be much in favour of combining the old plan, of much-curved isogonals taking detailed account of the observations, with the new plan carried however to its logical conclusion, of quite plain lines disregarding *all* small anomalies. That is, one may suggest that future editions of these maps should give isogonals like those of the 1928 edition (of course embodying any corrections indicated by further observations) together with bolder isogonals, at 1° intervals, showing the general trend of the isogonals. These might be accompanied by a rubric similar to that now introduced in the 1933 maps, though preferably with the omission of the prophecy contained in the last sentence.

One new feature in the 1933 edition which seems to be wholly commendable is the indication, by shading, of the magnetically disturbed regions where great anomalies are probable, rendering it useless to draw isogonals in those regions.

S. C.

THE EVOLUTION OF ROMNEY MARSH

The *Archaeologia Cantiana*, vol. xlv, contains a paper on "The Evolution of Romney Marsh," by Mr. C. J. Gilbert. The account begins with the local conditions in late Palaeolithic times, when the sea-level was about 70 feet lower than at present, but nevertheless water occupied the site of Walland and Romney Marshes and the waves lapped the higher ground to the north and west. In the course of the Neolithic Depression accumulations of shingle and sand from the up-channel drift were deposited in the bay to a depth of 70 feet, two sections of which are given, the one near the foothills and the other in the shingle flats several miles to the seaward. At the close of the depression the deposits are assumed not to have reached the low-water mark. The succeeding stage, initiated by a 25–30-foot rise of the land, was of major importance. It turned much of the bay into dry land on which forests of oak and hazel began to flourish, whilst a substantial shore beach was thrown up on the newly formed shore-line. A depression then set in which caused the sea to break through this shore beach in several places and flood the erstwhile wooded land behind. Salt-marsh plants encouraged the deposition of mud which covered the forest mould with a thin wedge of alluvium, increasing in thickness seawards with the fall in level of the forested surface.

A second uplift of small dimensions, pre-dating the Bronze Age, served to consolidate the water-logged marshes and to strengthen the shore defences, and this allowed the reclamation of the Romney Marsh. The succeeding depression brought the land to its present level and to it is attributed the exceptional ravages of the sea in the eleventh to fourteenth centuries, described by Lamblardie, Camden, Somner, etc.

Turning to the mystery of Dungeness, the author vigorously attacks the views of Gulliver (*Geogr. J.*, vol. 9, p. 536), but his own explanation goes little beyond suggesting that "the extension of the Ness seems clearly due to the fact that the shore-line has developed at such an angle to the dominant wind-waves as to arrest the shingle at a greater rate than it can be driven round to leeward by the less aggressive waves of the East Bay." In more recent times the Ness has been robbed of shingle by the growth of the Camber Castle ridges and has therefore been extended largely from the wastage of the southern shore.

The destruction of the natural barrier of shingle which once ran from Romney to the Hythe ridges is attributed to the intercepting of the shingle supply by the growing promontory of Dungeness. At the beginning of the nineteenth century it was necessary to construct the Dymchurch Wall to protect Romney Marsh from the inroads of the sea. Some of the shingle removed from this section of the shore was drifted southwards and formed the new Littlestone beach which, by nearly joining the northern extremity of the Dungeness ridges at Greatstone, has served to reclaim much fertile land between Romney and the sea. W. V. L.

MAPS OF DR. ROY CHAPMAN ANDREWS'S FOURTH CENTRAL ASIATIC EXPEDITION, 1928

The American Natural History Museum has lately presented to the Society the maps showing the results of the surveys carried out in 1928 on the fourth season in the field of the Central Asiatic Expeditions under the leadership of Dr. Roy Chapman Andrews. Unfortunately the Chinese civil war which was still in progress created difficulties for the expedition and prevented it crossing the Mongolian frontier; its explorations had in consequence to be confined within Inner Mongolia. Kalgan was again the starting-point and the first route taken lay westward, passing through Hatt in Sumu on the Kalgan–Urga road, along the former route to Shara Murun, where in 1925 fossil beds had been discovered, then to Pailing Miao whence the direction of the old caravan road to Turkistan was followed for 185 miles. Beyond this it was impossible to take the motor-cars owing to the drifting sand which filled the Go Yo To Basin on the northern edge of the Ala Shan desert, and the expedition was forced to turn back. After returning to Shara Murun the expedition went north to Iren Dabasu (Erhlien) and made several reconnaissance journeys to the east of the Kalgan–Urga road terminating at Ungur in Sumu a few miles south of Ar-Tsagan Nor where further progress was again blocked by impassable sand. The expedition made its way back to Hatt in Sumu, and after a final eastward trip of 75 miles to Hollock Tiami it returned to Kalgan.

The maps are in fourteen sheets, ten showing the routes traversed plotted in the scale of 1 : 200,000 with contours at 50-feet vertical intervals, while four are reconnaissance maps of special areas on larger scales as follows: Plate E, area east of the Shara Murun River in the vicinity of Jhama, Twin and Ulan Shireh Obos, Hospital and Spring Camps, scale 1 : 20,000, contours at 20-feet vertical intervals; Plate F, area north-east of Urtyn Obo, Baluchithere Camp, scale 1 : 12,000, contours at 10-feet vertical intervals; Plate G, area north of Gur Tung Khara Usu, Elephant Camp, scale 1 : 12,000, contours at 10-feet vertical intervals; Exhibits 6 and 7, Inner Mongolia Reconnaissance 1928, south from Sair Usu trail, scale 1 : 400,000, and north from Tukhum in Sumu along the caravan route from Kweihwating to Urga, scale 1 : 160,000. These and the twenty-eight sheets presented by Dr. Andrews in 1927 make a valuable contribution to the mapping of Inner and Outer Mongolia.

CORAL REEFS AND THE SNELLIUS EXPEDITION

In an interesting volume of the Geological Results of the Snellius Expedition, Part 2, Geology of Coral Reefs, Dr. Ph. Kuenen continues the work of Molengraaff and Umbgrove on the coral reefs in the Dutch East Indies. Dr. Kuenen has had at his disposal that new instrument of precision, echo-sounding, and one of the results is a detailed description of some of the deep-sea atoll groups, in particular of the Toekang Besi Groups. The highly plastic impression given by the profusion of soundings leads the author to the conclusion "that most of the atolls in the East Indies are found to crown deep-lying submarine ridges

from which they rise abruptly and very steeply to the surface, like chimney-pots from a roof." These two facts, the steepness of the slopes of the reef structures themselves even down to great depths, and the position of the reefs along the submarine ridges, relegate to a secondary position the influence of lowered sea-level in the Glacial Period; the author considers the reef structures to be entirely coralline and rejects not only the suggestion of coral superstructures above planed-down continental features, but also the theory of the formation of lagoons through the growth of corals round the edges of a planed-down coral reef. A lagoon is considered to be a natural feature of a large coral reef, although the mechanism of its formation is not at present understood. Dr. Kuenen therefore, especially when he states that the formation of most atolls precedes the pleistocene lowering of sea-level, reaches a conclusion which is very closely in agreement with Darwin's theories.

A great part of the account is concerned with the island-reefs of shallower seas. Numerous maps, photographs, and detailed descriptions are to hand in which the terminology of the Great Barrier Reef Expedition is used. The precision of the description is in itself an extremely valuable feature of the report. The same general conclusion is reached for the East Indian island-reefs as was reached for those of the Queensland Coast, namely that probably most islands have been formed as a result of emergence of their flats and then in the sequence sand-cay, shingle-ramparts. Here again the closer observation of detail has been a productive line of work. It remains now for the expedition which will follow in Dr. Kuenen's footsteps to give the precise meaning, which a single-handed worker could not give, to such statements as that sand-cays reach a very regular height above sea-level, and that a living reef cannot grow up above low-water level; while its principal energies will be directed to the problem of the balance of growth, solution, and sediment in the lagoons of atolls. M. A. S.

REGULATION OF EXPLORATION IN BRAZIL

In July last the Foreign Office, by direction of the Secretary of State, informed us that a dispatch had been received from His Majesty's Ambassador at Rio de Janeiro reporting the publication of a decree laying down the conditions to be fulfilled by expeditions exploring the interior of Brazil. The Ambassador had enclosed a translation of this Decree, No. 22,698 of 11 May 1933, which imposes on the Ministry of Agriculture the task of supervising foreign and private national expeditions of any sort, on the grounds that incursions into the national territory by expeditions, which had not previously notified the Brazilian Government, are becoming more frequent; that it is necessary to prevent abuses and damage likely to result from such expeditions, and to protect natural, historical, legendary, and artistic monuments from the risks which they at present run. It is therefore decreed that foreign expeditions must apply for the authorization of the Ministry of Agriculture; that expeditions so authorized must be accompanied by Brazilian members appointed by the Government; that the expenses of these members will be charged to the expedition unless the expedition is judged to be of national interest; that no specimens may be removed unless there are duplicates in the National Museum; that scientific material collected by foreign missions must be divided in equal parts between the Brazilian Government and the expedition; and that no natural, historical, legendary or artistic monument may be removed abroad without the express authorization of the Government.

In January 1934 the Foreign Office communicated further the translation of a second Decree signed by the Chief of the Provisional Government on 31 October 1933 creating the Council for the supervision of artistic and scientific

expeditions referred to in the Regulations issued by the Brazilian Government on 28 June 1933 to give effect to the first Decree. The Council is charged with the duty of supervising licensed expeditions and the export of any objects found by them. They have to decide what deposit must be made to cover the expenses of the Brazilian representatives, to designate these representatives and draw up their instructions, and to carry out many other formalities. If the expedition is judged to be of national interest it may be accompanied by an expert appointed by the Ministry and paid for by the Government, who may grant passages, transport, and pecuniary assistance. Similar concessions may be granted individually to scientists of recognized reputation. The export of unique or rare specimens will not be permitted. Expeditions not considered to be of national interest must bear the expenses of the Government representative, and make a deposit to cover the salary and field allowances for the maximum duration of the expedition.

The above are the principal provisions of these regulations, which may be seen on application to the Society. They apply to the whole of Brazilian territory and apart from any mitigation which might be obtainable through diplomatic channels, practically amount to an embargo on all exploration in Brazil.

ADMIRAL WILKES AND THE ANTARCTIC CONTINENT

In his note on the return of the *Lively* from Enderby Land in 1831, Dr. H. R. Mill observed on p. 232 of the March issue of the *Journal* that the impression appeared still to prevail in America that Admiral Wilkes was the first to recognize the continental nature of Antarctica and to give it the name of a continent. Mr. Edward W. Dalton writes from Los Angeles to say that in his opinion the American view could be better expressed in the words "that Admiral Wilkes was the first actual explorer who, sighting an area of Antarctic land now thought to form part of the continent, recognized it as forming part of the continent."

Dr. Mill informs us that he gladly accepts that as an authoritative statement of the present American view. It does not of course affect the fact which he tried to stress that Biscoe was the first explorer to sight land now known to be part of the Antarctic continent.

CAPTAIN COOK'S FIRST VOYAGE

It is generally recognized that there are numerous differences between the various records of Captain Cook's first voyage, and that the journals underwent editing. The question has recently been re-examined by Mr. Frederick Watson in a pamphlet 'Lt. James Cook and his voyages in H.M. bark *Endeavour*' (Sydney, 1933), in which he draws very sweeping conclusions. This study is largely founded upon the journal in Cook's autograph now in the National Library, Canberra. He points out, for example, that the log-books use the name "Stingray Harbour (or Bay)" which is altered in the journal to various forms of "Botany Bay." This, and similar changes in nomenclature, he argues, were made in England on Cook's return. (There are however facts which tend to disprove this, as G. A. Wood points out in his 'Discovery of Australia.') Mr. Watson concludes that the National Library journal was put together by Cook from his log-book and portions of the "original" journal, but that the greater part of the latter was rewritten "under official instructions and censorship" in England. The final postscript—"the Dolphin's voyage and this of ours published by authority to fix the prior right of discovery beyond disputes" has been altered by Cook by the insertion of "not" before "published"; this, the author thinks, strengthens his case that this journal was prepared "to claim possession by prior right of discovery under the belief that the Dutch or some other nation were the first discoverers" *i.e.* of the eastern coast.

The points upon which he bases this contention are not convincing—for example, Cook's remark in his letter from Batavia: "Altho' the discoverys made in this voyage are not great, . . .," and a phrase used by Barrow in 1824, ". . . our own example of taking possession of the eastern coast and the island of Van Diemen, the original discovery of which by the Dutch is not to be disputed"—which is ambiguous.

His main argument rests upon a statement of Cook's referring to the voyage of Quiros: "Altho' we found in most Charts his discoveries placed as far to the West as this country [*i.e.* the east coast of Queensland] yet from the account of his Voyage, . . . we are Morally certain that he was never upon any part of this Coast." From this he argues that Cook must have been given by the Admiralty several charts, now unknown, showing land in this position, and that these were obtained secretly from other nations. But the author, despite his statement, has apparently not consulted the 'Carte générale' in De Brosses's 'Histoire des navigations,' which shows Quiros's discoveries, inscribed "Cote de N^{a} S^{a} de Luze ou T. du S^{t} Esprit" in the approximate position of eastern Queensland. Cook may have been a little inaccurate in writing "most charts"—but the assumption of the existence of a series of secret maps is not justified. He also favours the suggestion that "Botany Bay" was derived from the "Coste des Herbaiges" of the Rotz map of 1542—but if the object was to conceal a prior discovery, any similarity of names would have been avoided.

EARLY EARTH-MEASUREMENT

It is well known that Eratosthenes, the first of the early Greek geographers to undertake actual measurements to determine the size of the Earth, obtained by this means the figure of 252,000 stadia as the measure of the Earth's circumference. His successor, Posidonius, followed by Marinus and Ptolemy, gave the figure as only 180,000 stadia, and they have been reproached by some with accepting an estimate far less near the truth than that of their predecessor. Others have sought to explain the discrepancy by supposing that the length of the stadium was not a constant quantity among the ancients, but that two different standards were in use, standing in the ratio of 3 : 4 to each other: a view which would also explain various inaccuracies to be found, for example, in Ptolemy's maps. But though the guess seemed plausible it has hitherto lacked proof. Evidence in its favour has been lately found by Professor Von Mžik, of Vienna, in the work of the Armenian mathematician Ananias of Shirak (*c.* 620–705 A.D.), which on account of its language has not been so carefully studied as it might otherwise have been (*Forschungen u. Fortschritte*, 20 January 1934). This man, though learned, showed no originality in his writings, but this very fact gives them a certain value as they put on record the views of still earlier Greek savants. He expressly states that besides the commonly used stadium, of which seven went to the mile of 1000 double paces, there was another, employed for measurements "in the air-line," which measured 107 double paces. The proportions are thus, according to his rounded figures, as 107 to 143, or almost exactly as 3 : 4, the ratio needed theoretically to harmonize the divergent values of the Earth's circumference. Professor Von Mžik finds that, translated into modern units, the Posidonius value may be put at 38,057 km., that of Eratosthenes at 39,960, as against the true value of 40,075. This surprising degree of accuracy may partly be due to the mutual compensation of different errors. The work of Ananias also helps to determine the length of the mile generally used in the east in old days, of which 75 went to the degree, and the writer ends by pointing out how the influence of these old units has continued to be felt down to our own day.

AN EIGHTEENTH-CENTURY MAP OF PRUSSIA

One of the biggest cartographical undertakings before the nineteenth century was that of a great map of Prussia begun by Count Schmettau in 1763, which eventually embraced no fewer than 200 hand-drawn sections, mostly on the large scale of 1/50,000. A good deal of obscurity has shrouded the history of the map, some of which has now been cleared away by the researches of Berthold Schulze, who sets forth the results in an interesting article printed in the *Mitteilungen des Reichsamts für Landesaufnahme* 1933/34, Nr. 4. (The sheets of the map were transferred in 1919, with many other documents of the kind, from the Archives of the General Staff to the Map Department of the Prussian State Library.) It was once thought that the work was started under the orders of Frederick the Great, but this is a mistake, that sovereign having in fact been averse to anything of the kind as likely to be dangerous if it came into an enemy's hand. Apart from this, uncertainty has prevailed as to the precise part played by Schmettau, as attempts were made in his lifetime to discredit him and to make it appear that his claims to have done a large part of the work at his own expense were unfounded. In a detailed statement put together by him in refutation of the charges made, brought to light by Herr Schulze, we have the most complete account existing of the inception and whole progress of the work, and if it is to be trusted it shows that the temporary disfavour into which he fell with the King (Frederick William II), whose whole-hearted support he seems to have enjoyed while Crown Prince, was the result of dishonourable Court intrigues. He had once before been forced to leave the army owing to the offence given by his outspoken criticism of the military conduct of the Bohemian war by the former king, but had been reinstated. Herr Schulze finds that his account appears trustworthy on the face of it and that it has some support from independent sources, and particularly from the fact that he was eventually restored to favour and to the Army, his death in 1806 being the result of serious wounds received in battle when holding a high command. It is interesting to note that the inception of the great map of Prussia was due to his realizing the wholly inadequate nature of previous maps as a basis for military operations. It was in part based on earlier work, but when this proved inadequate new surveys were carried out. In the latter stages of the task Schmettau had a coadjutor in the person of Schulenburg-Kehnert, a relative of the Minister Schulenburg, and it seems that the two men divided the country between them by agreement, though it is uncertain in what precise way the partition was carried out.

OBITUARY

MR. CARSTEN E. BORCHGREVINK

We regret to record the passing of a distinguished Antarctic explorer in the person of Carsten Egeberg Borchgrevink, who died in Oslo on April 21 after a long illness. Borchgrevink was born in Oslo in 1864, his father being Norwegian, his mother English, and at the age of twenty-four he went to Australia, where he found employment as a schoolmaster teaching languages and natural science. He travelled pretty widely in Australia, and in 1894 gratified his adventurous disposition by shipping on board the *Antarctic*, a Norwegian whaler bound for the Ross Sea. The venture was financed by the famous whaling pioneer, Svend Foyn, and organized by Mr. H. J. Bull under the command of Captain L. Kristensen. The *Antarctic* made the first trip to the Ross Sea since the voyage of the *Erebus* and *Terror*, more than fifty years earlier, and Borchgrevink had the satisfaction of being a member of the first party to land, near Cape Adare, on the Antarctic Continent. On his return to Australia he hurried to England and reached London just in time for the International Congress of 1895, where important discussions on the renewal of Antarctic exploration were taking place. He read a paper on the voyage of the *Antarctic*, and his youthful enthusiasm made a deep impression on such veterans of Antarctic exploration as Sir Joseph Hooker, Sir John Murray, and Dr. G. von Neumayer. The announcement of the discovery of living plants within the Antarctic Circle produced a thrill which it is still a pleasure to remember.

Encouraged by his reception Borchgrevink tried hard to organize a new expedition in accordance with the resolution of the Congress that exploration in the far South ought to be resumed before the close of the nineteenth century. He received no help from our Society, which, under the determined guidance of its President, Sir Clements Markham, was promoting a national Antarctic Expedition on a scale of unprecedented magnitude. Markham indeed actively opposed Borchgrevink's ambition as likely to diminish the support of the larger scheme by the public; but Mr. Ll. W. Longstaff, the chief financial backer of the National Expedition, exclaimed cheerfully "the more the merrier." Borchgrevink went on until he gained the good will of Sir George Newnes, who bore all the expense of an expedition under the British flag in the *Southern Cross*. This ship left the Thames in August 1898 under the command of Captain Jensen, who had been first mate of the *Antarctic*, with Lieutenant W. Colbeck, R.N.R., as chief officer. Borchgrevink made a successful landing near Cape Adare, and erected a hut so well and truly put together and fastened down that it stood the storms of that blizzard-smitten coast for thirteen years, when it was found still serviceable by Scott's Northern party. The wintering party included Mr. L. C. Bernacchi as physicist, and Mr. W. Hansen, of the British Museum (Natural History), whose death cast a gloom on the expedition. It was found impossible to climb the ice-covered plateau or to make progress for any distance along the coast; but meteorological observations were kept up during the first winter which human beings had passed on Antarctic land, and large zoological collections were made. The ship returned in the spring and passing southward sighted Mount Erebus, and coasted the great Ice Barrier, the position of which was fixed as half a degree south of that determined by Ross. The first landing was made on the Barrier which Ross had believed to be inaccessible. A level surface was discovered and sledged over to 78° 50′ S., a higher latitude than had been previously reached in the South.

The *Southern Cross* returned to Australia in April 1900, and Borchgrevink

came to England, where his reception lacked enthusiasm. This was due in some measure to causes arising from his youth and inexperience in leadership. He was blamed for want of tact in his relations with his staff, and for his failure to make journeys into the interior. The English edition of his book 'First on the Antarctic Continent' was marred by an attempt to make it attractive by adopting the style of the popular journalism of the day. The Norwegian and German versions are much fuller and give a more satisfactory account of the expedition. At the time of its publication attention was concentrated on the National Antarctic Expedition, and, like Hooker and Doughty before him, Borchgrevink had to wait more than a quarter of a century before receiving the Patron's Medal as the seal of this Society on his pioneer work. By that time the results of Scott's last journey had shown that the conditions of exploration from a base near Cape Adare were far more difficult than was formerly thought, and that the remarkable thing about Borchgrevink's earlier expedition was not that it had failed to do more but that it had escaped from an untenable position with energy enough left to make the first journey on the surface of the Great Barrier. The courage and tenacity of Borchgrevink as an explorer were completely vindicated.

The good work done by the other members of the *Southern Cross* Expedition was recognized at the time, and their experience utilized by Mr. Bernacchi's appointment as physicist on the *Discovery* and Lieutenant Colbeck's employment as Captain of the *Morning* on the relief expeditions of 1903 and 1904.

Borchgrevink returned to Norway with his English wife and continued to interest himself in scientific pursuits. He is survived by Mrs. Borchgrevink, two sons, and two daughters. His eldest son, Ridley Borchgrevink, is an artist of talent who has travelled widely and whose 'Svart og Hvit i Afrika' ('Black and White in Africa') contains a series of vivid black-and-white sketches of native people and animals. H. R. M.

DR. J. MACKINTOSH BELL

Dr. James Mackintosh Bell, O.B.E., PH.D., LL.D., the well-known geologist and mining engineer, died at Almonte, Ontario, on March 31 at the age of fifty-six. He was born at St. Andrews in the Province of Quebec in 1877, and received his education at Canadian institutions and finally at Harvard University, where he took the degrees of M.A. and Ph.D. In 1899 he joined the Geological Survey of Canada, with whom he worked for four seasons under his uncle, Dr. Robert Bell, who was at that time Director. Until the outbreak of the War, Dr. Bell spent many active years in geological work in Canada, in New Zealand, and in Asia. It was he who conducted the survey of the Great Bear Lake and the Mackenzie River for the Canadian Government. In 1905 he was appointed Director of the Geological Survey of New Zealand, a post which he held until 1911, when he returned to Canada to become consulting engineer and geologist to Messrs. Hamilton, Ehrlich, and Turk.

During the War he served with the 73rd Battalion, Canadian Expeditionary Force from 1915 to 1917, when he was attached to the British Military Mission in Russia. For nearly two years he worked with the Intelligence Branch in Siberia, returning to Canada in 1919. He had been a Fellow of our Society since 1901.

Dr. Bell's publications included, in addition to many official reports to the Canadian and New Zealand Geological Surveys, 'Tales of the Red Children' (in collaboration with Miss A. F. Brown), 'The Wilds of Maoriland,' and 'Sidelights of the Siberian Campaign.' He married in 1909 Miss Vera Margaret Beauchamp, of Wellington, New Zealand, by whom and by two sons he is survived.

Twelfth Evening Meeting, 30 April 1934. The President in the Chair

Elections: Hugh Brown; Mrs. Flora Mary Crocker, O.B.E.; John William Radclyffe Dugmore; George Hudson Earle; H. C. S. Grubb; Miss Iris Olive Marie Harris, B.A.; Miss Gwendoline M. Henry; William Stanes Luly, B.A.; J. Maxwell W. Main; Miss Rachel Janet Owen; Major Charles Henry Page, D.S.O.; E. H. Lane Poole; John Richard Pope; Harold Slater, B.SC.; James Olivant Smith; John Archibald Tebbs, B.A.; J. P. Underhill, B.A.; G. E. Whitrod; Miss Grace Winram

Paper: The Himalaya East of the Tsangpo Gorge. By Mr. F. Kingdon Ward

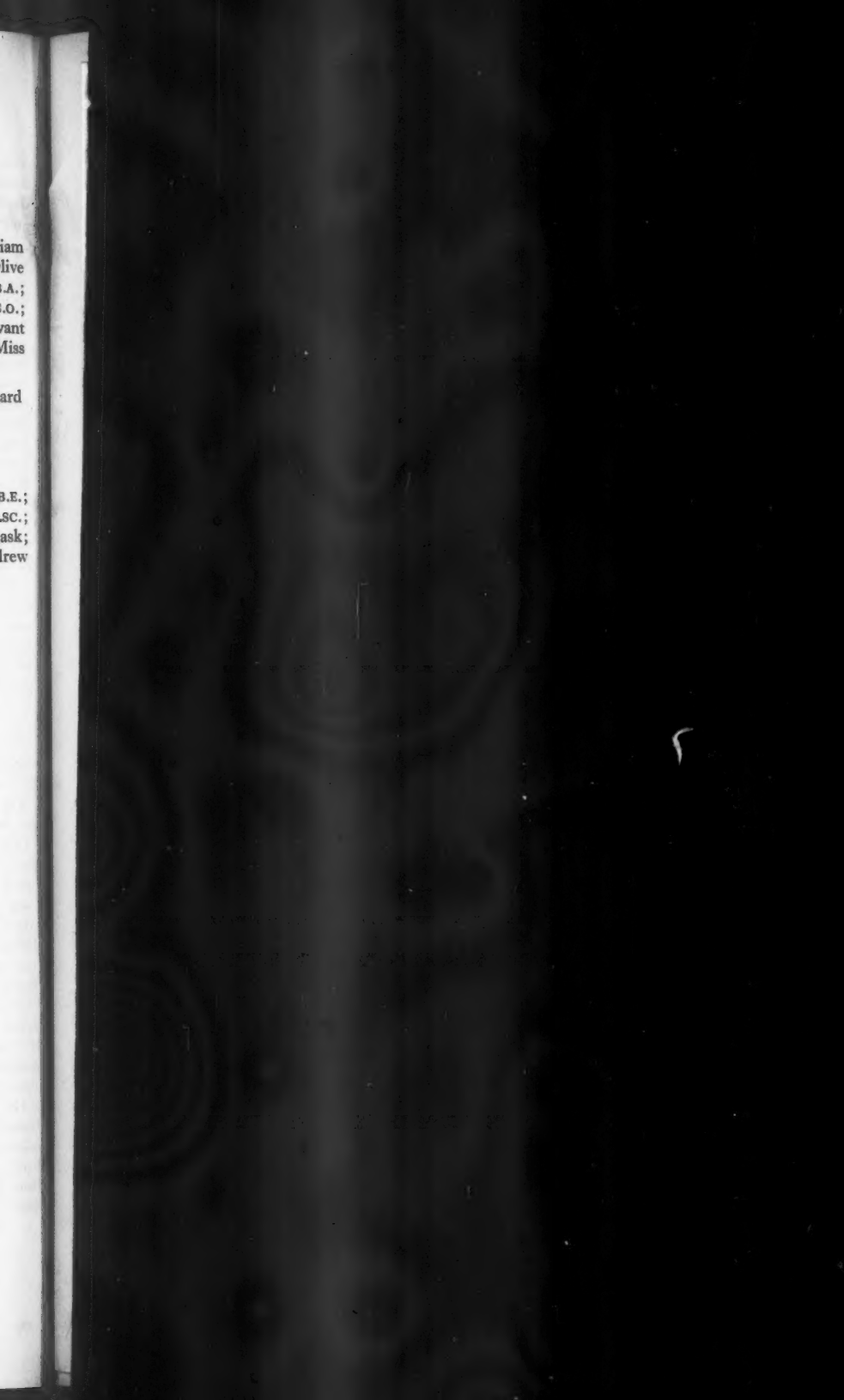
Seventh Afternoon Meeting, 7 May 1934. The President in the Chair

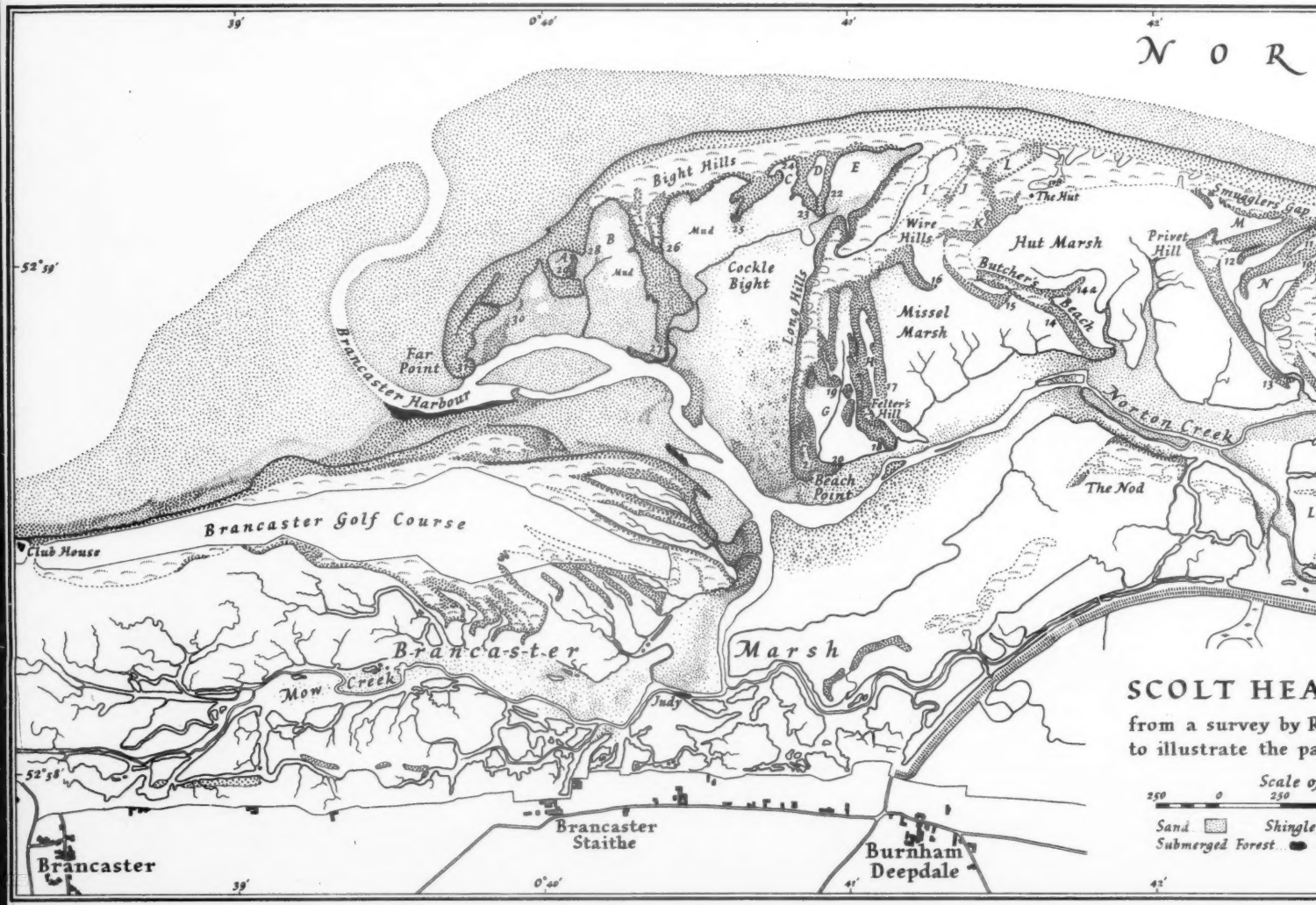
Paper: Lake Victoria in the Pleistocene. By Dr. L. S. B. Leakey

Thirteenth Evening Meeting, 14 May 1934. The President in the Chair

Elections: Gordon Stuart Campbell, B.A.; Miss Julia Chatterton, M.B.E.; Brigadier Eric Felton Falkner, C.M.G., D.S.O.; Horace James Francis, B.SC.; Miss Olive Garnett, B.A.; G. W. Harley, M.D.; James Henry Graham Leask; John Lewis Lee, M.A.; David Reginald George Mason; Lieutenant Andrew Uniacke Hacket Pain; John Pickston, B.SC.; Lieutenant R. Walker, R.N.R.

Paper: Ajaristan and Lazistan. By Mr. W. Rickmer Rickmers

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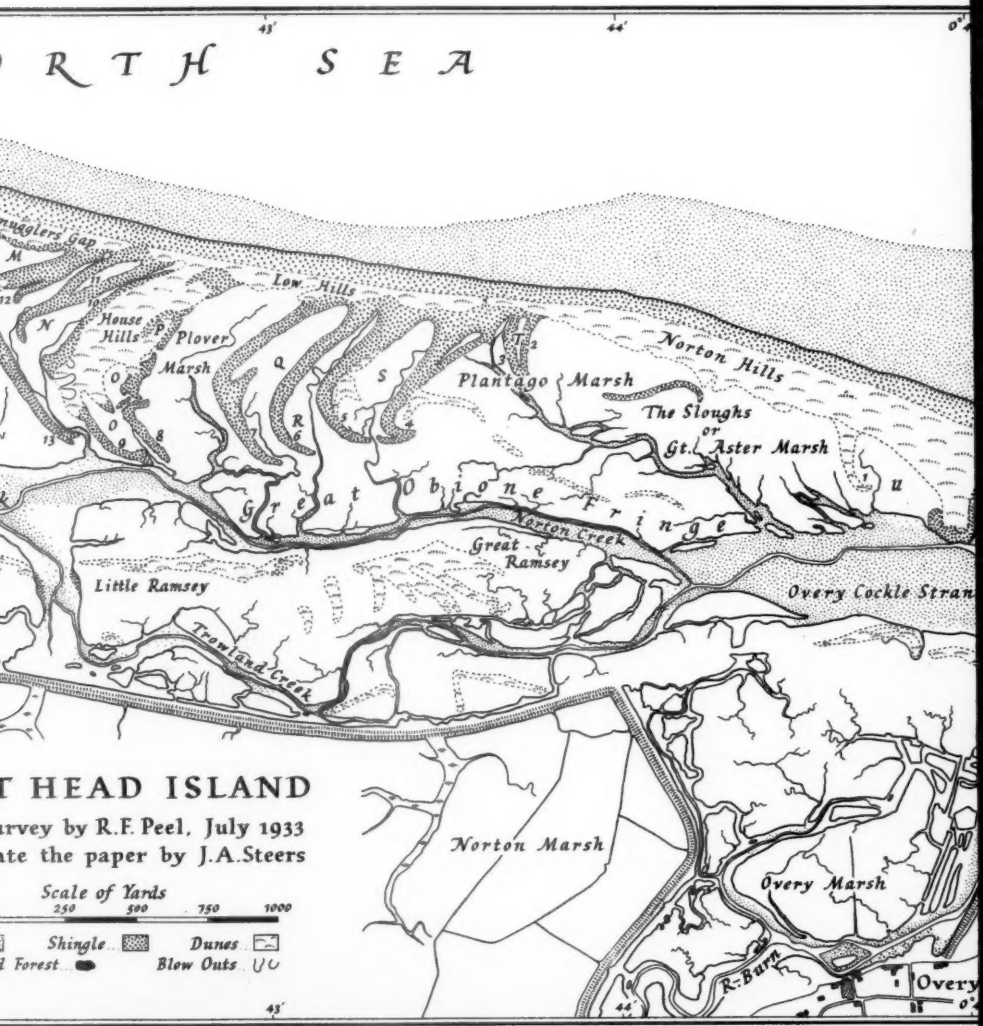
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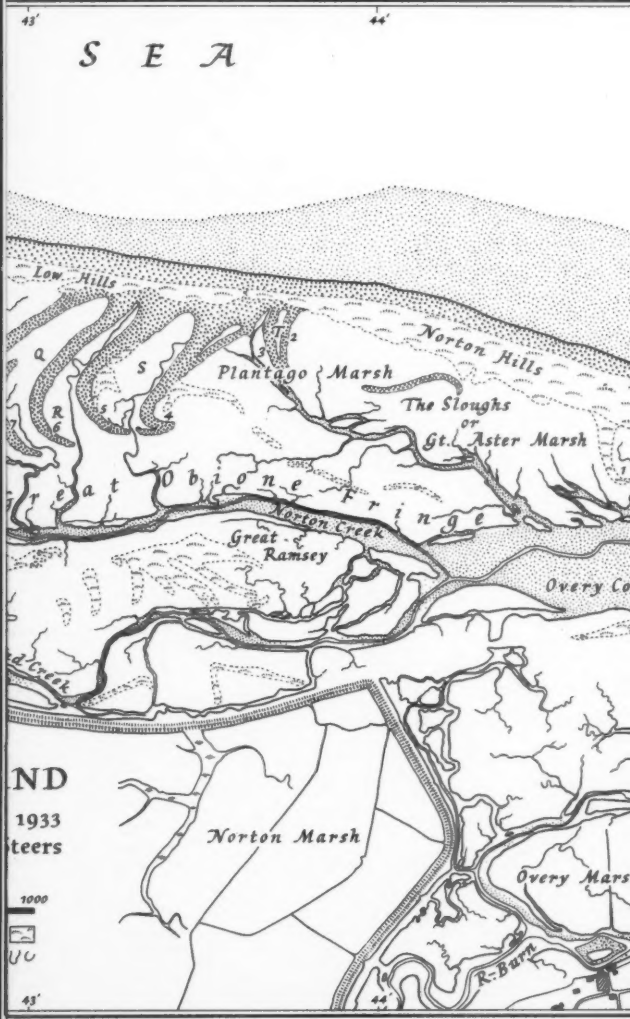
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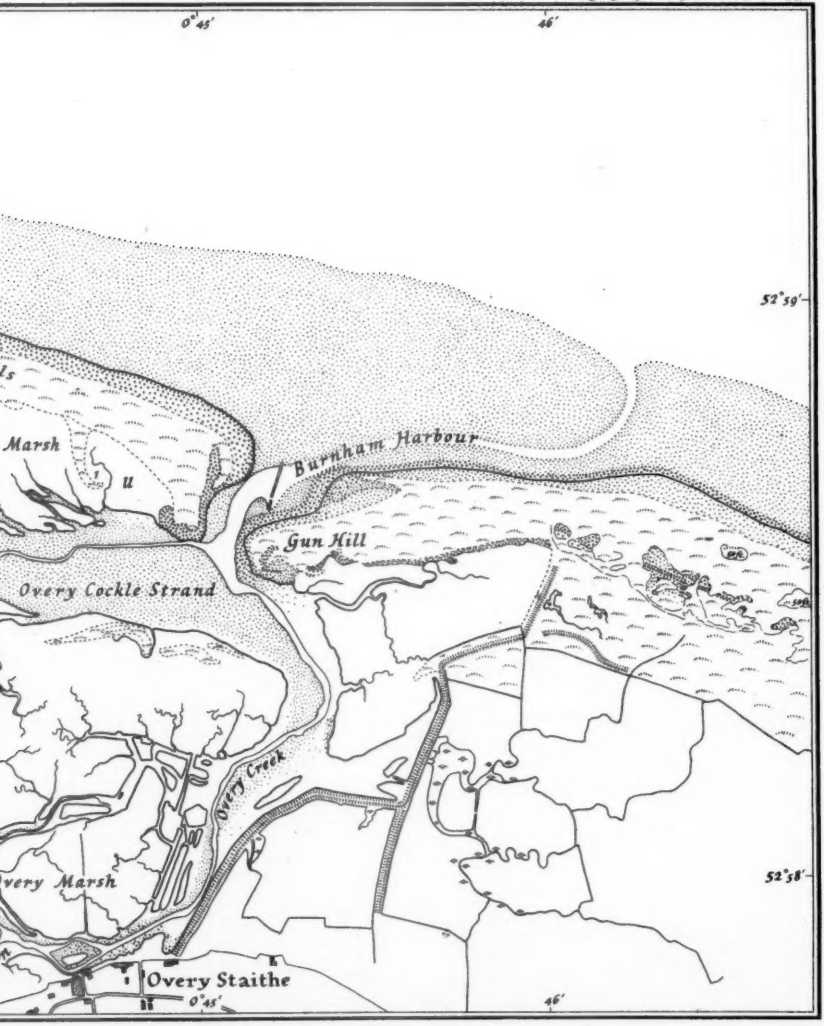
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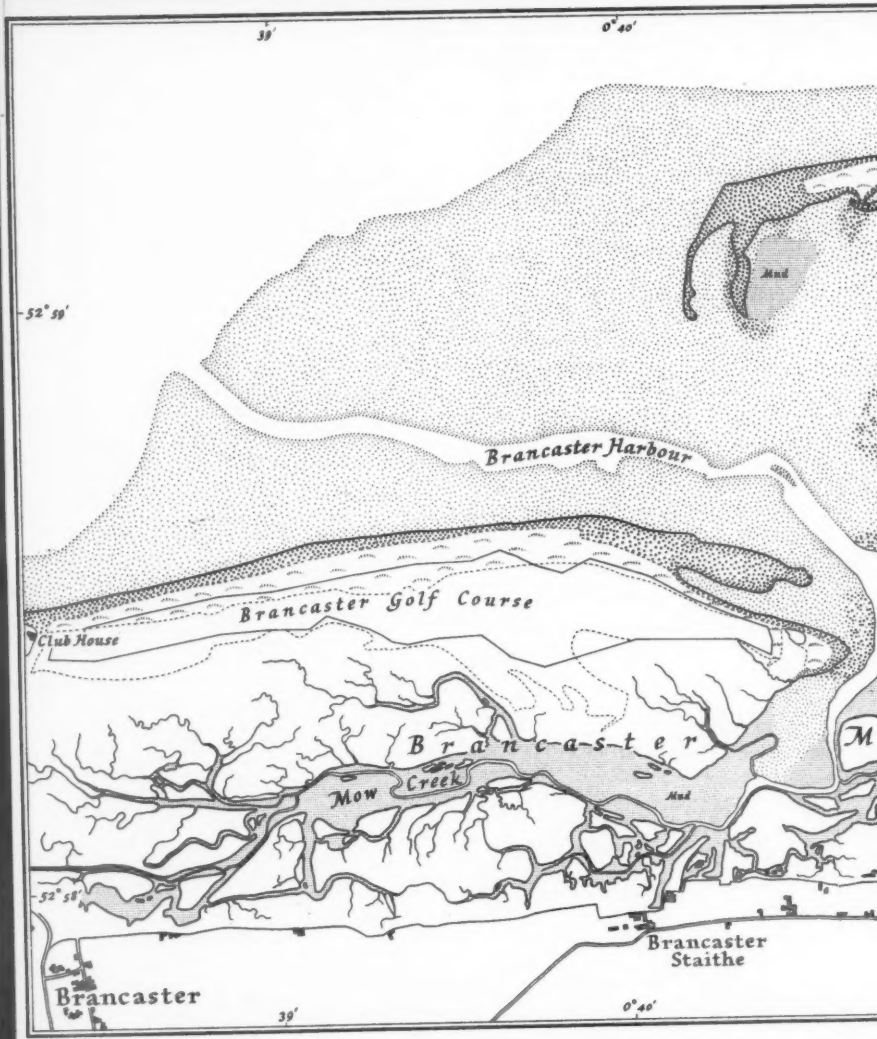
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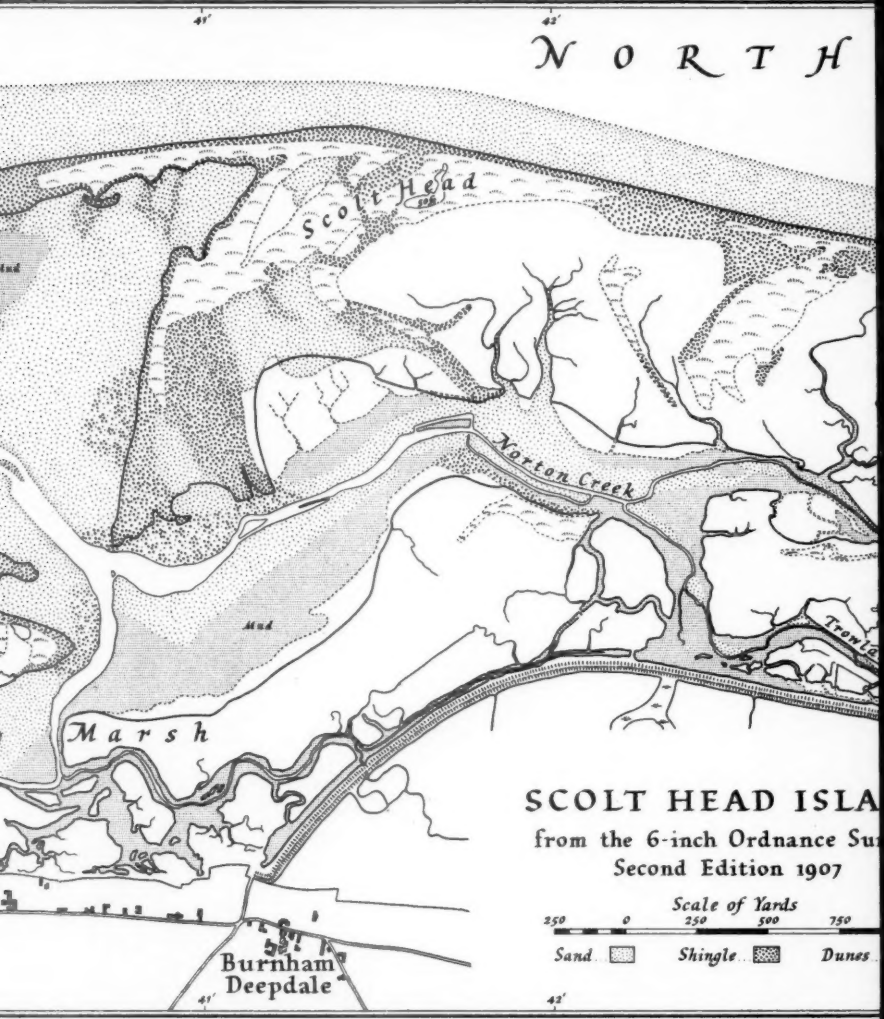

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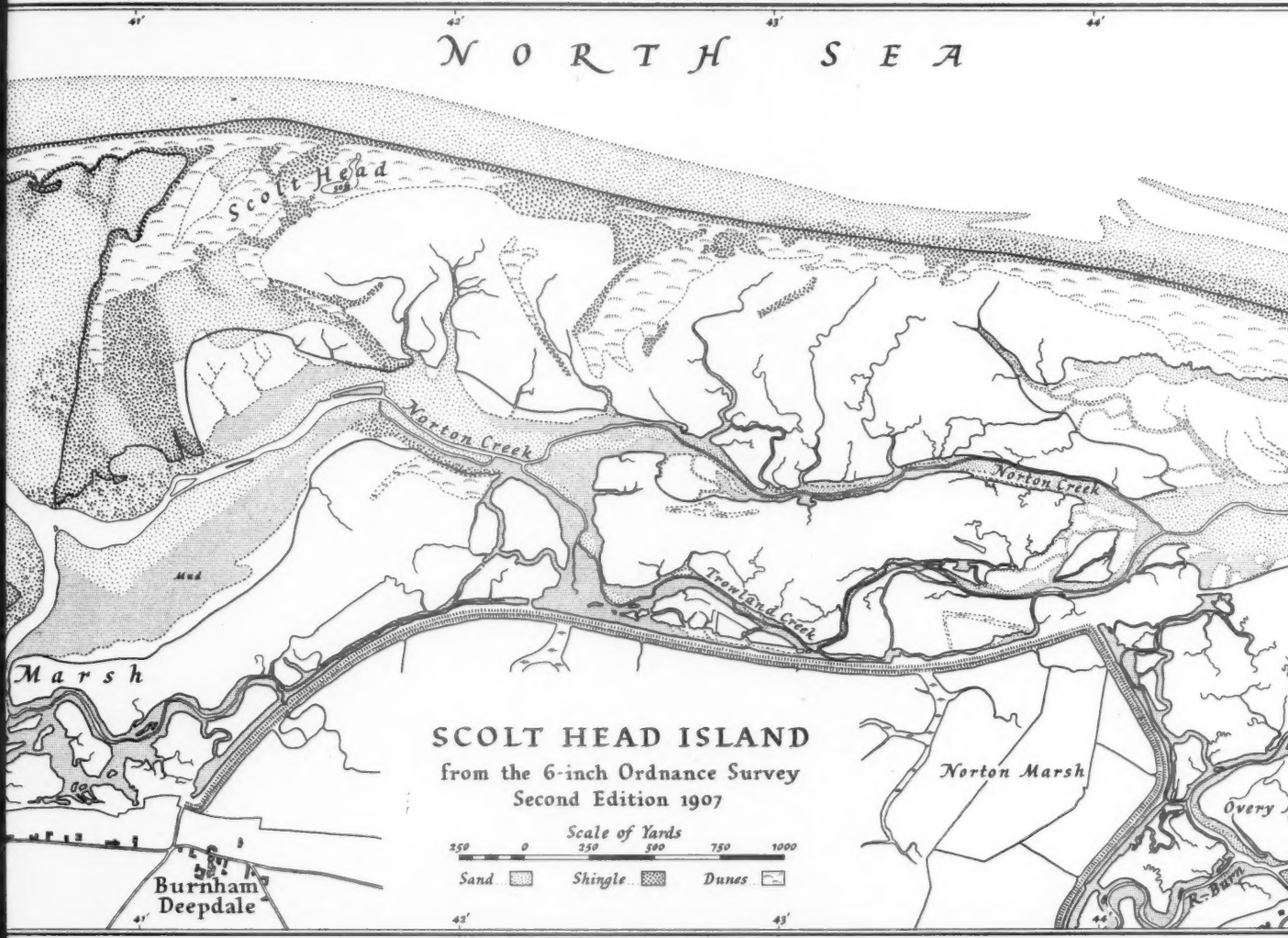

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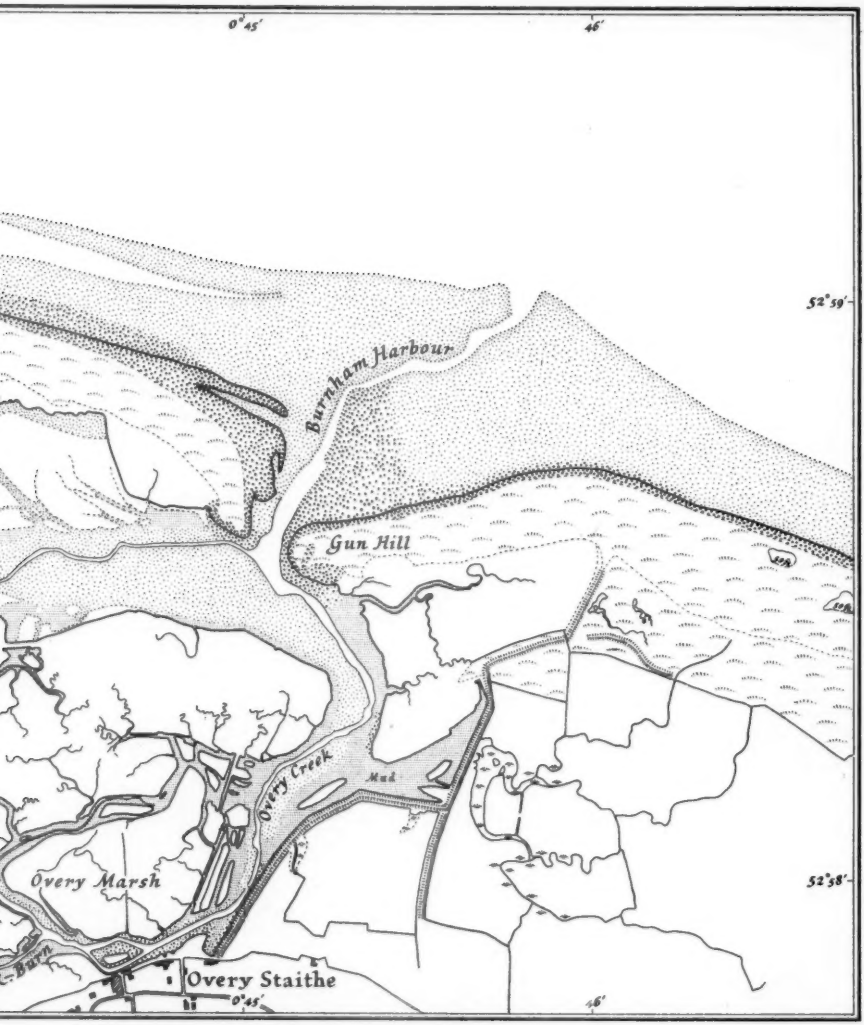

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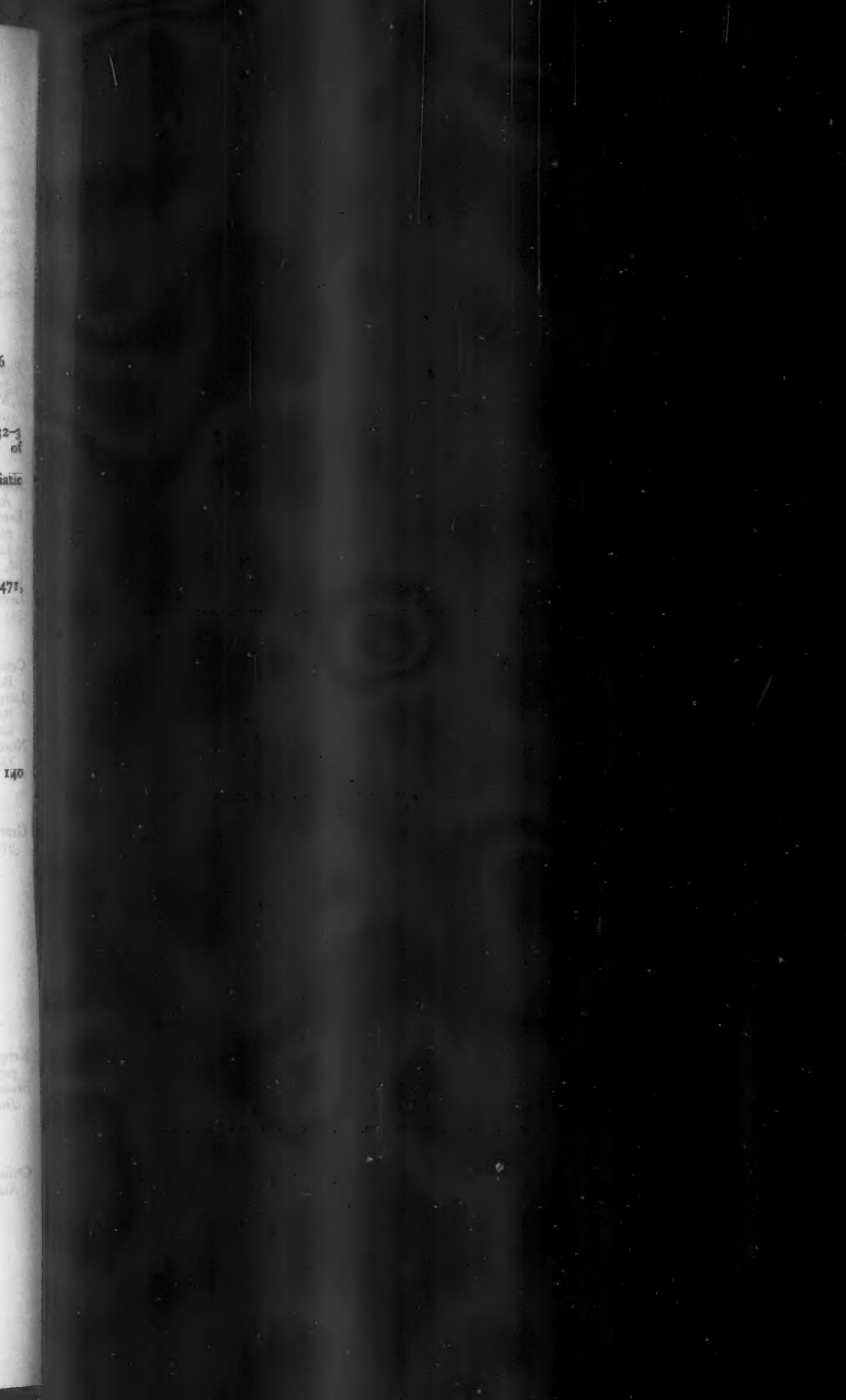
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